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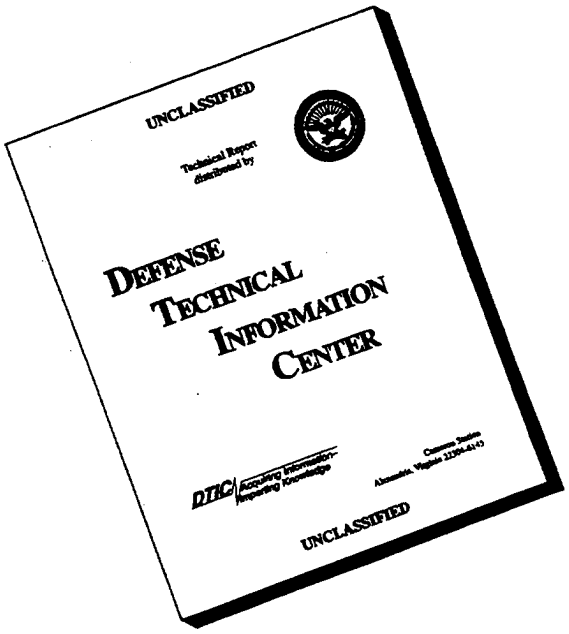

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FORCE XXI FIELD ARTILLERY:
KING OF BATTLE OR TWENTY-FIRST CENTURY DINOSAUR?

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

THOMAS S. YOUNG, MAJ, USA
B.A., Claremont Men's College, Claremont, California, 1981

Fort Leavenworth, Kansas
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ABSTRACT

Force XXI Field Artillery: King of Battle or Twenty-First Century Dinosaur? by MAJ Thomas S. Young, U.S. Army, 147 pages.

This thesis studied the future material systems, organizational structures, and operational concepts of the Force XXI artillery to determine the readiness for the challenges of the twenty-first century. The research design focused on the ability of the future artillery force structure to effectively support the Force XXI patterns of operations, conduct military operations across the spectrum of conflict, and the integrate appropriate new technologies. The main emphasis of the thesis was on evaluation of the ability of the future artillery to effectively support Force XXI patterns of operations. The thesis concluded that the future artillery force structure is sound. The future artillery can effectively respond across the spectrum of conflict. The future artillery has a comprehensive strategy to identify and integrate the technologies it will need in the twenty-first century. The thesis recommended changes to the artillery force supporting the Army's light divisions. Specifically, the future artillery must improve it's strategic mobility and early entry lethality and survivability. Recommendations included: development of an ultra-light weight 155mm towed cannon, a wheeled self-propelled 155mm cannon, and FA brigades tailored for light forces.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

> Yes, we have slain a large dragon. But we live now in a jungle filled with a bewildering variety of poisonous snakes. And in many ways, the dragon was easier to keep track of.[1]
>
> James Woolsey, Force XXI America's Army of the 21st Century.

> We appear to be plunging into a new dark age of tribal hate, planetary desolation, and wars multiplied by wars.[2]
>
> Alvin and Heidi Toffler, War and Anti-War

The United States faces a future of tremendous change and much attendant risk. According to many respected theorists and visionaries, the twenty-first century will usher in an international security nightmare, as increasingly frequent and violent conflicts erupt along a myriad of social, cultural, political, and economic faultlines. The future is likely to be less "new world order" and more "the coming anarchy." Against the backdrop of CNN "Headline News" filled as it is with secession movements demanding nationhood, genocidal "ethnic cleansers," criminal syndicates, mercenary forces, have-gun-will-travel fanatics, and various two-bit strong-men and Saddam-clones, the emergent global system takes on an increasingly sinister look.[3] It is a future seething with potential violence in which anyone's military edge, including even that of the United States, could be offset or even neutralized in new and unexpected ways.[4] Indeed, as we enter the new millennium it seems clear that "the future ain't what it used to be."

In this dismal and all too possible future it seems sure that the U.S. military will stand increasingly at the fore in safeguarding national and global interests. Current trends in the international security arena indicate a growing need for, and reliance on, the use of military power, as other means of national power are found less and less effective. The ability of the U.S. military to respond effectively to the controlling factors of the twenty-first century will be of grave consequence, not only to the U.S. but to the world as a whole.

At this point in time, the U.S. Army is attempting to transform itself from the premier twentieth century, Industrial Age army to the premier twenty-first century, Information Age army. This fundamental metamorphosis is in response to a number of external factors and considerations. Figure 1 shows the complexity of the process and the many variables. These many elements of change create force structure decisions for the Army of the twenty-first century. What the Army will look like, how it will fight, and its success on the battlefields of tomorrow hinges on the force structure decisions made today.

The new strategic environment poses many significant challenges for the U.S. Army. The entire contextual framework of U.S. Army operations has been remade since the end of the Cold War, moving from the relatively predictable scenarios of the past to the more complex and unpredictable ones of today. We no longer face a monolithic foe with uniform doctrine and equipment, allowing us to singularly focus on how we plan, equip and train to fight.[5] Instead we now face a wide variety of security threats ranging from extremely complex joint and combined military action against well-equipped regional powers, or a newly emergent peer competitor, to small unit actions against "machete-swinging clans of warlords" and other transnational threats. The scope and

complexity of the future threat is depicted in the threat spectrum model (see figure 2). The uncertain nature of the potential threat, and the increasing potential for conflict across the entire spectrum of military operations, requires the U.S. army to create a flexible and adaptive force structure capable of addressing a multitude of conflict scenarios.

Added to the uncertain threat is the challenge inherent in the transition from a forward based army to a power projection army. The end of the Cold War and subsequent lack of a well identified and compelling external threat combined with domestic budgetary demands to recast the American Army in a new mold. This shift in strategy requires significant change in how the U.S. Army will fight. The majority of conflicts in the twenty-first century are likely to be quick and dirty, "come as you are" affairs, placing a premium on rapid response, early entry forces that are survivable and lethal. Force structure planners no longer have the luxury of a forward deployed army to support contingency operations around the world. Force structure planners must design a force that can be rapidly projected into an austere theater of operations, conduct decisive operations, survive and sustain.

These challenges are compounded by the broad range of tasks and missions that will fall to the Army in the twenty-first century. Force XXI soldiers and units must be equipped and trained to execute not only traditional military operations, but also the burgeoning number of missions to be found under the banner of military operations other than war. President Clinton made the extent of the mission scope clear when he stated:

> You will be called upon in many ways in this new era to keep the peace, to reduce suffering, to help teach officers from new democracies in the ways of a democratic army and still . . . to win our wars.[6]

Peacekeeping, peacemaking, humanitarian assistance, and disaster relief operations are becoming increasingly common missions for the Army. These good Samaritan missions will place American soldiers increasingly in harm's way, and significantly expands the potential for conflict at the low end of the threat spectrum. There are many people who will see in an American soldier a threat and a target, no matter how altruistic the American mission.

In addition to the sweeping changes occurring within the international affairs arena, the strategic environment of the twenty-first century will be profoundly altered by the ongoing technological revolution. It should not be assumed that the United States has a monopoly on the current Revolution in Military Affairs (RMA). The modern tools of war provide the American military an unprecedented ability to bring death and destruction down on an enemy. However, any period of continued technological superiority is likely to be short. Advances in technology will provide new combat capabilities that will revolutionize the future battlefield in five key areas: lethality and dispersion; volume and precision of fire; integrative technology; mass and effects; and invisibility and detectability.[7]

The nature of war and how it will be fought may be on the brink of fundamental transformation. Some have written that combined arms warfare, the endstate for twentieth century warfighting, is coming to an end. Futurists Alvin and Heidi Toffler assert that we are in the midst of a profound revolution in military affairs that will see the existing forms and balance of military power shattered.[8] It is possible the battlefields of the twenty-first century may not even involve the current elements of combat power, that entirely new dynamics of power will emerge. If so, we cannot afford to be found unready.

The proliferation of weapons and technology will be the most serious challenge to U.S. military superiority. Technology knows no borders. The civilization of the tools of war has intensified the "acceleration of deadly invention." Our force structure must reflect the fact that potential foes can go from "no-tech to high-tech in the flash of an arms deal." The market availability of military and dual-use technology places a wide variety of weapons and support systems within reach of anyone with serious intent.[9] It is becoming increasingly possible that a hostile state or entity will make technological leaps in areas of critical technology: weapons of mass destruction, information operations, and space control. We must expect that critical information age technology will be available to whomever has the means and desire to obtain it.

Potential adversaries need not modernize their entire military capability. Canny foes will quickly realize that success on the battlefield may hinge on an asymmetric or niche capability and will selectively pursue hardware and technology that will deny the U.S. the ability to bring its considerable military power to bear. The most highly traded weapons of the 1990s have been surface-to-air missiles, something that should give pause to even the most ardent air power enthusiasts. Nor should we ignore threats armed with less sophisticated weaponry, many industrial age weapons can still kill quite effectively. The tactical effect of mines is out of proportion to their technological threshold and cost, witness their effect on naval operations in the Persian Gulf and land operations in Bosnia.

History commonly documents the fact that technological change almost always outstrips military thought. Nations and their armies have all too often found themselves on the wrong end of the cutting edge of technology and paid the price with the blood of their citizens. If we

are not to pay this price then we must anticipate the dramatic and far-reaching effects of the information age revolution, rather than be dragged along by the course of future events.

All of these challenges must be resolved in a time of declining military resources and increasing requirements. The military is told to do more with less. Since 1990 the Army has seen its budget reduced about 40 percent and its manpower by 450,000.[10] The Army has dramatically slashed its active duty force structure from eighteen divisions to the current ten, and there is the strong possibility that the number of active duty divisions will drop even further. The reserve components have seen similar reductions. These force reductions have coincided with an increased military operational tempo, as fewer units are assigned increasing numbers and varieties of missions. There has been a 300 percent increase in operational deployments since 1990.[11] An Army that is spread increasingly thin across the globe increases the risk that some renegade may take action. Clearly the remaining force structure of the world's sole superpower must be extremely flexible and versatile and even more capable than before.

The Army faces an additional challenge in that expectations remain high: "The expectation of large numbers of casualties in a prolonged conflict has been replaced with the expectation, and the requirement, for versatile, lethal forces that can attain swift, decisive victories with minimal casualties and minimal collateral damage."[12] The American people demand not only victory, but speedy victory. The "100-hour war" is the new standard. It is expected that not only will we win America's wars, but we will do so as bloodlessly as possible. Not only must American casualties be minimized, but those also of the opponent. Collateral damage must be avoided through the use of smart and brilliant

weapons able to conduct "surgical strikes." The American public and the media expect quick and total victory, at the least cost in lives.

Technology offers many advantages in meeting these many challenges. However, future defense budgets will remain lean, with fewer and fewer dollars available for initial research, development, testing and evaluation (RDT&E) of emerging technologies. Also, the current pace of technological development is so great that it threatens to render our existing material management and acquisition system inadequate.[13] Our current acquisition system was designed to provide new systems to combat a clearly defined threat in a period of relative stability in an environment of consistent resourcing and measured technological advances. Today, time and money are both in short supply. Today's threat is nebulous and fleeting with an uncertain event horizon. Today's technological solutions can become tomorrow's problems almost overnight.

Force development is something akin to peering into a crystal ball. Looking into the future and correctly divining the capabilities that will provide future success is not an exact science. This is particularly true in a period of revolutionary change when change is measured more in terms of orders of magnitude rather than incremental improvement. However, the amount of personnel, funding and time available to perform detailed combat development analyses and studies is in short supply. These shortfalls are occurring at the time when the Army needs its brain trust most.

The U.S. has a limited window of time available to make its critical force structure decisions. At this point in time in time there is no immediate threat that can seriously harm U.S. national security interests. We currently have military and technological advantages that should allow us the opportunity to design and build an Army for the future. "Pax Americana" is the peace dividend of the Cold War. However,

history shows that the status quo can be quickly overturned when the existing order is overtaken by fundamental and dramatic change. Military supremacy is a short-lived thing in a period of RMA.

However, we must make our selections with proper deliberation and care. Modern technology offers an astonishing array of possibilities that can be pursued in the search for the most versatile and lethal force multiplier. Decision makers must choose carefully or come tomorrow we may find that we have invested in obsolescence. Today's "silver bullet" technology might well be tomorrow's equivalent of horse cavalry charges against armored fighting vehicles and machine guns. Decision makers must consider,

> technologically we are riding a change wave that threatens to make present and pending technologies rapidly obsolete. New weapons bought today may provide ten years or so of superiority--which we already have, anyway--but, as general research accelerates purchases delayed until after the turn of the century may offer a full generation or more of advantage.[14]

Force XXI--America's Army for the twenty-first century--is the Army plan to address the strategic environment of the future. Army leaders intend to translate emerging technological capabilities into the warfighting capabilities the U.S. Army will need to protect U.S. interests. Force XXI will combine improved systems and innovative force structure with new operational concepts to create a force endowed with near real-time situational awareness, and the capability to rapidly focus overwhelming firepower during high tempo operations. General Gordon R. Sullivan describes the intent and process as follows:

> Force XXI will leverage the capabilities of the latest technologies to optimize the skill and courage of our soldiers. We will integrate information age technology with our tactical units. We will redesign units, built around people and new technologies, to enhance their agility, versatility, and lethality.[15]

The Force XXI end state is a force that is more lethal, survivable, capable of sustained high tempo operations, deployable,

versatile and sustainable, with increased joint and combined connectivity.[16] Force XXI is an information-based force that derives combat power from the synergistic effects of providing all the battlefield operating systems (BOS) a common relevant picture of the battlefield. Force XXI is also a power projection force that must be capable of winning the first battle, no matter what and no matter where. Force XXI is further defined by the following patterns of operation, which define the critical capabilities the future Army must possess:

1. Project the Force
2. Protect the Force
3. Gain Information Dominance
4. Shape the Battlespace
5. Conduct Decisive Operations
6. Sustain and Transition

These patterns of operation and the capabilities that the field artillery (FA) component of Force XXI will need to support them is the primary research issue of this thesis. The Army commitment to the Force XXI vision of technology and warfighting requires an extremely coordinated force modernization effort by the branches. The field artillery must be fully synchronized with the rest of the Army in its approach to force modernization, we can not afford a "loose cannon."

The U.S. Field Artillery Center and School (USAFACS) at Fort Sill, Oklahoma, has identified weapons and other material systems, and is investigating doctrinal and organizational changes to achieve synchronization with Force XXI. Vision 2020 articulates Fort Sill's plan for the field artillery component of Force XXI. The stated intent is to establish revolutionary new concepts for the artillery, creating "moving hornet's nest of combat power" through the integration of new technologies. For the purpose of this thesis Vision 2020 is used as an

all-encompassing term that refers to the artillery material, organizational and operational initiatives that are emerging from Fort Sill. This thesis examines the capability of these proposed FA force developments to support Force XXI. Vision 2020 also includes initiatives in the areas of training, leadership, and soldiers. However, Vision 2020 initiatives in these areas will not be considered in this thesis.

As we enter the twenty-first century it has been said that we stand at "the threshold of a major change for the combined arms team--the ascendancy of fires."[17] Under the ascendancy of fires concept the intent is fight the enemy by fire first, and then by fire and maneuver, so as to avoid the exposure of our forces to the effects of enemy fires. Force XXI units will use long-range fires as the spearhead of the attack to the extent that the ground maneuver forces may only need to mop up after the fires.[18]

This thesis will examine this potential ascendancy of fires and determine if it is feasible and/or likely with the systems, organizations, and concepts of Vision 2020. An attempt will be made to identify any material, organizational, or conceptual shortfalls that may hamper the field artillery's ability to deliver the ascendancy of fires. Military history is replete with examples of the cycle of combat power swinging between fire and maneuver. The thesis examines the ascendancy of fires concept and attempts to determine if it indicates a fundamental realignment of the dynamics of combat power or if it is only a passing thought.

Research Questions

The primary research question is: Does Vision 2020 propose an appropriate US field artillery force structure for the twenty-first century? Supporting questions include:

1. Does Vision 2020 propose an appropriate US field artillery force structure to support the Force XXI patterns of operations?

2. Does Vision 2020 propose an appropriate US field artillery force structure to respond across the spectrum of conflict in the twenty-first century?

3. Does Vision 2020 propose an appropriate US field artillery force structure to adapt to the emerging technologies of the twenty-first century?

Significance of the Study

The rapidly evolving nature of the geostrategic environment, changes in the nature and conduct of war, the rate and scope of technological advances pose major challenges to the architects of Force XXI. The twenty-first century will be a brutal and unforgiving operating environment if the U.S. Army develops the wrong force structure. U.S. national security interests may be severely harmed if we are unable to mount a credible military capability. If we get it "too badly wrong," the costs will be tremendous.

In the years since the First World War, the artillery has held the position of the principal killer on the battlefield, accounting for 50-70 percent of all casualties during major conflicts. The ability to mass and deliver large volumes of fire has been at the heart of much of the U.S. success in battle during this period.[19] This ability is likely to remain the basis for decisive victory in any conventional military operations. In the twenty-first century the Force XXI field artillery must continue to provide flexible, responsive, and effective fires in all tactical conditions at all times. An Army without effective recourse to the "final argument of kings," *ultima ratio regis,* is an Army without a knockout punch.

However, the field artillery of Force XXI must also be flexible and versatile enough to meet the challenges of relevancy in the less conventional MOOTW missions and low-intensity conflicts that will likely comprise the bulk of Force XXI operations. Recent experience suggests that the traditional role of the field artillery, and the utility of firepower in general, is diminished in these types of conflicts. The artillery must anticipate the demands of these types of missions if we expect to remain pertinent to the challenges of the twenty-first century.

We must be sure to select and use technology appropriately if we are to build the right force for the twenty-first century. If not, we run the risk of building the most expensive and irrelevant white elephant in the history of mankind.[20] We cannot afford, literally and figuratively, to design a force that is in danger of imminent technological or tactical obsolescence.

Definition of Key Terms:

Ascendancy of Fires. This term refers to a fundamental change in the relationship between fire and maneuver. General (Retired) Glenn Otis describes the ascendancy of fires:

> What that means is that we, as a nation, will fight conventional battles using firepower of all kinds from longer ranges, much of it indirect--not eyeball-to-eyeball using direct fire. We'll use long-range fires as the spearhead of the attack to the extent that the ground maneuver forces may only need to mop up after the fires. That's a totally different concept of operations. This concept aims at achieving decisive results while minimizing the usual high casualties of the direct fire battle.[21]

Close Support Fires. Fires used to engage enemy troops, weapons or positions that are threatening or can threaten the force in either the attack or defense. Close support fires allow the maneuver commander to rapidly multiply the effects of combat power, and shift fires rapidly throughout the battlefield. Close support expands battlefield depth, erodes enemy forces, and inflicts damage well beyond direct fire ranges.[22]

Counterfires. Fires used to attack enemy indirect fire systems, to include mortar, artillery, air defense, missile, and rocket systems. Observation posts and field artillery command and control facilities are also counterfire targets. Counterfire allows freedom of action to supported maneuver forces.[23]

Field Artillery Mission. The mission of the field artillery is to destroy, neutralize, or suppress the enemy by cannon, rocket, and missile fires and to integrate all supporting fires into combined arms operations.[24]

Field Artillery Roles. The field artillery system provides close support to maneuver forces, counterfire, and interdiction as required.[25]

Fire Support. Fire support is the collective and coordinated use of indirect fire systems, armed aircraft, and other lethal and non-lethal means in support of a battle plan. Fire support includes mortars, field artillery, naval gunfire, air defense artillery in secondary mission, and air-delivered weapons. Non-lethal means are electronic warfare capabilities of military intelligence organizations, illumination, and smoke.[26] The principal fire support element in synchronizing maneuver and fires is the field artillery.

Fire Support System. Fire support is the product of a three part system of systems:[27] (1)Fire support command, control, and coordination (C3) facilities and personnel; (2) Target acquisition and battlefield surveillance; and (3) Fire support resources, weapons and munitions.

Interdiction Fires. Fires used to disrupt, delay and destroy enemy forces that, because of range limitations or intervening terrain, cannot fire their primary weapon system on friendly forces. Targets include first-echelon forces not participating in the direct battle and follow-on echelons. Interdiction fires create "windows of opportunity" for friendly unit offensive movement.[28]

Joint Precision Strike. The objective of joint precision strike is to accurately and responsively attack time sensitive high-payoff targets. Joint precision strike provides the commander the means to influence the enemy with precise, lethal fires that maximize the employment of all assets available to the joint force.

Revolution in Military Affairs-- Although analysts of the RMA are not in complete agreement on a specific definition most have accepted general definitions stressing a "discontinuous increase in military capability and effectiveness." The writers of TRADOC Pamphlet 525-5 have adopted Andrew Krepinevich's definition that a military revolution:

> occurs when the application of new technologies into a significant number of military systems combines with innovative operational concepts and organizational adaptation in a way to fundamentally alter the character and conduct of conflict. It does so by producing a dramatic increase-often an order of magnitude or greater-in the combat potential and military effectiveness of armed forces.[29]

Sensor to Shooter. Sensor to shooter refers to the links running from target acquisition "sensors" through command and control (C2) nodes down to weapons platforms "shooters." Sensor to shooter TTPs are designed to provide the capability to attack the enemy in the minimum time possible and take away his ability to operate within the friendly commander's decision cycle. Sensor to shooter provides the capability to rapidly engage targets with lethal fires by establishing procedures for processing information to meet the requirements of specific tactical situations.[30]

Targeting/Decide-Detect-Deliver-Assess (D3A). Targeting is the process of identifying enemy targets for possible engagement and determining the appropriate attack system to be used to capture, destroy, degrade of neutralize the target in question. This targeting methodology is frequently referred to in shorthand as the D3A cycle. The *decide* phase establishes what parts of the enemy force the commander wants

attacked, the priority of attack, the effects desired, the preferred attack means, and where. In the *detect* phase the specified targets are acquired so that they can be engaged. Then the friendly force must *deliver* the means to achieve the desired effects. Lastly, the friendly force must *assess* the results of its attack to determine in the desired results were achieved, which then feeds back into the decide phase. The D3A cycle is an ongoing process repeated continuously throughout the operation.

Scope and Limitations

The U.S. field artillery stands at a point of extraordinary change, facing great challenges and offering great potential. This thesis proposes to determine if the artillery is poised for revolution or mere evolution. The scope of this thesis consists of a critical analysis of proposed Force XXI field artillery force developments and force structure initiatives against a framework of critical aspects of the fast approaching twenty-first century. The thesis includes research, analysis, conclusions and recommendations, and an evaluation of the potential for the ascendancy of fires.

Combat developers and other designers of Force XXI must consider all aspects of the Training and Doctrine Command (TRADOC) domains of doctrine, training, leadership, organizations, material, and soldiers (DTLOMS) to effectively answer the challenges of the twenty-first century. However, this thesis is limited to the three aspects that impact most directly on force structure:

1. Material change. The acquisition and fielding of material systems with new technologies and improved capabilities to respond to these new conditions.

2. Organizational change. The reorganization and restructuring of the force to respond to these new conditions.

3. Doctrinal change. The development of new operational concepts, and revised tactics, techniques and procedures to respond to the new conditions.

This thesis concentrates on the artillery weapons systems, organizational structures and operational concepts portrayed in the Mobile Strike Force (MSF) exercises conducted at the Command and General Staff College at Fort Leavenworth, Kansas. The Mobile Strike Force (MSF)and Prairie Warrior (PW) exercises constitute a major part of the Army's campaign to design Force XXI. TRADOC is leveraging these exercises as advanced warfighting experiments (AWE). The intent of these experiments is to design a land combat force using the Battle Lab inputs that feature the material systems, organizational and operational concepts derived from TRADOC Pamphlet 525-5, Concept for Force XXI Operations, to significantly increase the lethality, survivability and tempo of land combat in the twenty-first century.[31] These MSF experiments provide the most current representations of Force XXI force structure and operational effectiveness. These experiments include the field artillery systems, organizations, and operational concepts expected to be in the field by the year 2010. The MSF is not touted as an objective organization, but rather a vehicle used in Force XXI Advanced Warfighting Experiments to assess division level design principles. The PW and MSF 1996 AWE represents the best available data at this point in time.

The future artillery force structure is still developing. Two major artillery force structure decisions have been announced in recent months. These were the decisions to reorganize cannon battalions under the three by six configuration, and to increase the allocation of FA Brigades in support of a committed division from one to two. For the

purpose of this thesis the future artillery force structure is defined as the artillery force portrayed in the PW and MSF 1996 AWE, modified by the two most recent force structure changes mentioned above.

Given the nature of the fire support "system of systems," it is exceptionally difficult to analyze any given piece of the system in isolation. The final effects of fire are dependent on a multitude of factors that all impact on timeliness, accuracy, and terminal effects. Target acquisition and command and control (C2) systems contribute as much to the overall effects of fire as do the actual delivery platforms and munitions. A comprehensive evaluation of the effectiveness of the artillery should address the entire system of systems. However, since artillery force modernization efforts and force structure design currently revolves around the manning and support of the guns, this thesis will limit its evaluation to this portion of the fire support system.

Another limitation of this thesis is that I had to rely on existing modeling efforts to determine the force effectiveness contributions of the Force XXI artillery force structure. I did not have access to any additional modeling resources that would enable exploration of any separate factors and conditions, or comparisons to other alternatives. However, the modeling data and analysis I used was the same data presented to senior Army leaders and decision makers involved in the design of Force XXI. Also, I had to assume that the developmental systems of Force XXI would perform as required, unless there was specific evidence to the contrary. However, this assumption is one that Army force developers also made in conducting their analyses.

Another limitation of this thesis is that it is an unclassified document, which required that some data be omitted. However, this did not significantly affect the presentation of the analysis, or the final

conclusions and recommendations. Also, I had no access to any special access programs (SAP) that may be investigating potential "leap-ahead" technologies. There may in fact be "black programs" currently in development that are exploring unknown Information Age technologies and weaponry that will revolutionize the way we wage war, but any such programs would be beyond the scope of this thesis.

Thesis Structure

To answer the thesis questions, the research addresses such key issues as: Force XXI patterns of operation, projected field artillery capabilities and limitations, the nature of future conflicts, and the nature of emerging technologies. Chapter 1 provides the background for the thesis question, establishes the significance of the study, and provides key terminology.

Chapter 2 contains a review of the literature and studies related to the thesis questions. The literature review is organized with general comments, trends and patterns, and key works. Included in the literature review are summaries of current manuals, pamphlets, reports, periodicals, articles, and books related to Force XXI, the emerging security environment, emerging technologies, and the field artillery.

Chapter 3 addresses the research methodology used for the thesis. The research methodology describes the process and techniques used in examining the primary and secondary research questions. The hierarchy and relation between research questions and issues is established. Each research question is further described and the evaluation criteria is established. Measures of goodness are introduced.

Chapter 4 presents the analysis of the information gathered during the research and literature review. The organization of chapter 4 parallels the structure of the research methodology described in chapter

3. Chapter 4 begins with a summary of the major changes to the future artillery force structure, its systems and organization. Then I presented in the analysis of the primary and secondary research questions, a combination of analytical techniques in answering the primary and secondary research questions:

1. Use of military judgment to establish and evaluate subjective criteria.

2. Use of comparative analysis to evaluate subjective criteria.

3. Use of modeling/simulation data to evaluate force effectiveness issues.

4. Review of critical assumptions made in government analyses and decision processes.

Chapter 5 contains the conclusions and presents the recommendations for future field artillery force structure decisions and also, included are recommendations for areas that merit additional study. Also, contained in chapter 5 are my conclusions regarding the potential for the future ascendancy of fires.

CHAPTER 2

LITERATURE REVIEW

General

There was sufficient literature available to conduct adequate research for this thesis, although one author in this arena laments that:

> it is *hard* to find a book which presents the principles of field artillery tactics, how these have developed with experience against the background of changing strategy and technology, and what the future may hold as a consequence.[1]

Because this thesis examined developmental systems and preliminary operational concepts and organizational structures, much of the available research material was in draft form and some critical source material was literally only "one slide deep." Because almost all the future artillery systems and organizations are developmental, their actual operational performance characteristics are estimates.

Trends and Patterns

Government sources provided most of the key works for this thesis. Government manuals and pamphlets defined the principles and characteristics of Force XXI. A number of studies, papers and briefings document the future artillery weapons systems, and their organizational and doctrinal framework. The studies and analyses backing these documents identified assumptions and criteria used in the design of the future artillery. Combat developer requirements documents for Force XXI FA systems (Mission Need Statements (MNS), Required Operational Capabilities (ROC), and Operational Requirement Documents (ORD) provided information regarding specific system performance requirements and

potential capabilities and limitations. Individual weapon systems Cost and Operational Effectiveness Analyses (COEA) provided information regarding critical assumptions and quantitative force effectiveness measures. The Advanced Field Artillery System (AFAS) COEA, Sense and Destroy Armor (SADARM) COEA, and the ATACMS Block II COEA were particularly useful documents.

The secondary source literature in this area could be categorized as either historical reference or technical description of past and current artillery systems. I found no single work that answered the research questions I posed in this thesis. There were few significant works that focused on future force developments within the field artillery. There were no major works that examined field artillery force structure and doctrinal issues through the lens of Force XXI.

Typically the historical references provided a detailed analysis of a specific nation's artillery during a given period of time. These historical references were of value for their ability to provide insights into the impact that technology has had on the evolving roles and utility of the field artillery. The technical references typically provided a listing of equipment and their capabilities, with limited information regarding how they are employed. These references were of value for their detailed descriptions of system specifications and capabilities.

Articles from defense-related periodicals (such as Field Artillery, Military Technology, Jane's Defense Weekly, and International Defense Review) provided topical military information. The Field Artillery was an excellent source for current articles on the specific systems, and operational and organizational concepts that will be employed by the artillerymen of Force XXI. Technology related periodicals were reviewed to ascertain emerging or critical technologies that merit further research.

Key Works

TRADOC Pam 525-5, Force XXI Operations, was critical because it outlined the defining concepts and requirements of Force XXI. TRADOC Pamphlet 525-5 represents a baseline in the shaping of more definitive follow-on concepts for Army operations in the early twenty-first century.[2] In the foreword it is explicitly stated that TRADOC Pamphlet 525-5 is not a doctrinal publication, but rather a document of ideas. In its pages are described the force characteristics, battle dynamics and other attributes that serve to guide the design and development of Force XXI systems and concepts. The chapters on the future strategic environment and the nature of future land operations were particularly useful in helping to define the expected strategic, operational and tactical environments that the future artillery will operate in. The chapter on moving from concept to reality identified general and specific implications for the TRADOC domains of DTLOMS that are raised by Force XXI operations. These DTLOMS implications provided a general framework for the evaluation of Vision 2020 artillery material, organizational and doctrinal initiatives.

TRADOC's technical memorandum TRAC-TM-0194, Mobile Strike Force 2010, prepared by the TRADOC Study and Analysis Center provided an excellent source of quantitative and qualitative data and analysis. This report is the final report on the Prairie Warrior/Mobile Strike Force 2010 Workshop (PW/MSF 1994). This report describes the observations and analytical insights developed during the dual session MSF 2010 experiments held in May and June 1994. The purpose of the workshop was to provide input to the senior Army leadership to support decisions regarding Force XXI developments and to assess the impact of future technological capabilities and the organizational variations enabled by these new technologies.[3] TRAC used the Computer-Assisted Map Exercise

(CAMEX) to model the south west Asia (SWA) PW 94 MSF scenario with the MSF force structure, systems and threat updated to reflect expected 2010 capabilities. TRAC ran a base case scenario and six alternative excursions that varied the MSF technologies, tactical employment and organizational structures. These excursions provided force effectiveness data for selected artillery systems, organizations, and operational concepts in the context of Force XXI.

The PW/MSF 95 AWE Scripted Brief (September 1995) prepared by the Fort Leavenworth TRADOC Analysis Center (TRAC) provided the final results from analyses conducted in support of the PW/MSF 95 AWE. The purpose of the experiment was to assess division level design principles and operational concepts, and provide input for decisions regarding the development of Force XXI.[4] The scripted briefing provided only the most significant analytical results with regard to Force XXI division design. The results were summarized according to the most applicable Force XXI Pattern of Operations. Each pattern of operation is further described below:[5]

1. Project the Force--Deployment of the Force XXI force, rapidly tailored using mostly CONUS-based forces to overseas theaters, using prepositioned afloat and within-theater stocks.

2. Protect the Force--Protection of the Force XXI is enhanced through early warning provided by real-time intelligence, multi-dimensional joint air defense, limited visibility operations, and digitally supported Battle Command systems.

3. Gain Information Dominance--Force XXI wins the information war by providing continuous real-time intelligence preparation of the battlefield, "smart" jamming, automated sensor-to-shooter links, and protection of Force XXI information operation systems and activities.

4. Shape the Battlespace--Force XXI sets the conditions for simultaneous, decisive operations on the non-linear battlefield by employing systems with enhanced lethality and mobility, and by leveraging the advantages gained through information dominance.

5. Conduct Decisive Operations--Force XXI defeats the opposing force by delivering decisive blows with stunning force made possible by our ability to move decisively within his decision cycle.

6. Sustain and Transition--Force XXI maintains the momentum of its operations through split-based operations, predictive logistics enabled by real-time monitoring and feedback, and rapid transition to follow-on missions.

The PW/MSF 95 AWE organizational and operational analysis summarized in the scripted brief provided force effectiveness modeling data used to gauge the results of the future artillery material, organizations and operational concepts. This analysis used the Vector-In-Command (VIC) analytic constructive model and a series of TRAC developed force tailoring tools to evaluate MSF tempo, lethality, and survivability and develop Force XXI design applications in a north east Asia (NEA) Scenario.[6] TRAC examined additional MSF organizational concepts and technology alternatives beyond the base case portrayed in the PW exercise. The Center for Army Lesson Learned (CALL) formed a Combined Arms Assessment Team (CAAT) to collect observations on issues identified by TRADOC battle labs and proponents. The briefing concludes with a summary of the systems or initiatives that can be confidently recommended for integration into Force XXI, those systems or initiatives that require further experimentation, and those that can be discarded.

ST 71-100-2010 (draft), Mobile Strike Force 2010: Concept of Operations, took the organizational and operational concepts established in TRADOC Pamphlet 525-5, Force XXI Operations, and establishes

preliminary principles, tactics, techniques, and procedures for the division level digitized force as of 2010. ST 71-100-2010 provided the principles, tactics, techniques and procedures for use during PW/MSF 96 AWE. ST 71-100-2010 provided a detailed single source document for data regarding Force XXI material, organizational and operational concepts. ST 71-100-2010 is organized with chapters on MSF organizations, operations, battle command, information operations, offensive operations, defensive operations, and annexes detailing specific organizations and technologies. Six essential combined arms functions are identified:

1. Find and track the enemy throughout the battle
2. Deny friendly information
3. Fix the enemy
4. Maneuver the main effort to strike a decisive blow
5. Exploit the successes of the main effort
6. Facilitate transition to the next mission

Specific division level tactical methods (TTPs) to accomplish these functions are derived from the MSF organizations and operational concepts and system capabilities. This reference provided most of the data regarding MSF organizations and operational techniques for combat operations in the twenty-first century. For the purpose of this thesis, ST 71-100-2010 defined the division level TTPs that must be supported by the future artillery.

Brigadier General Leo Baxter's article "Field Artillery Vision 2020" in the December 1994 issue of the Field Artillery magazine helped to frame the scope of the transformation the artillery will undergo as it moves into the twenty-first century. Vision 2020 provides the conceptual bridge between the artillery of today and the artillery force of the year 2020.[7] Vision 2020 is the intellectual "catalyst" for the Force XXI artillery, identifying the doctrinal, training, leader, organizational,

material, and soldier developments required for the artillery of tomorrow. The driver behind the initiatives of Vision 2020 is the potential of new technologies. Brigadier General Baxter describes the future force in terms of specific capabilities that the artillery must support: unified combat power, an expanded battle space awareness, relevant common knowledge, and unified execution. Brigadier General Baxter then describes some of the conceptual requirements and material capabilities of the future artillery. This article provided the broad conceptual underpinnings for the systems, organizations, and operational concepts examined in this thesis.

The Army Science Board's 1994 summer study final report Capabilities Needed To Counter Current And Evolving Threats, released in April, 1995 provided an excellent source of data and analysis regarding the evolving security environment and the capabilities the U.S. Army will need to counter them. This Army Science Board study was sponsored by the Assistant Secretary of the Army for Research, Development, and Acquisition (ASARDA), the Deputy Chief of Staff for Intelligence (DCSINT), and the Assistant Deputy Chief of Staff for Operations and Plans for Force Development (ADCSOPS-FD). The specific terms of reference for the study were: (1) review the new worldwide threat situation; (2) identify and develop illustrative threat scenarios, both MRC and LRC, in terms of threat technological capabilities; (3) identify U. S. Army capabilities to counter the threats with emphasis on deployment, early entry and follow-on forces; and (4) prioritize U. S. Army capabilities needed to achieve decisive victory with minimal casualties.[8]

The key recommendations from the Study Panel were that the Army must: (1) develop/obtain more strategic lift that can deploy the necessary force structure faster; (2) reduce the risk to early entry

forces by the massive suppression and exploitation of enemy C4I; (3) defend early entry forces and follow on forces against enemy tactical missiles, artillery and armor by proliferating missiles and RPV defenses, and expanding the battlespace for counterbattery and anti-armor systems; (4) continue to develop the twenty-first Century Land Warrior as an effective dismounted capability; and (5) continue to digitize the Army.[9] This study highlighted the need for the Army to take immediate steps to improve the deployability, lethality, and survivability of its early entry forces. The study also brought out the contribution the field artillery could make to address the combat deficiencies of the early entry forces.

The Army Science Board's ad hoc study final report Innovations in Artillery Force Structure released in October 1995 provided an excellent source of data and analysis regarding artillery force structure requirements and initiatives. The study was sponsored by ADCSOPS-FD in response to senior leaders' concerns about the near term availability of FA force structure; lessons learned during Operation Desert Storm (ODS); and the continued downsizing of artillery force structure.[10] The specific terms of reference for the study asked two fundamental questions:

1. How much FA force structure is needed in the Army for the Fiscal Year 1996 time frame in order to accomplish the National Military Strategy?

2. If more artillery is needed, how should it be structured and resourced?[11]

The study made a number of recommendations, to include: (1) increase the Corps Artillery allocation rule from one FA Brigade, as currently structured, to two for each of the ten active component (AC) divisions; (2) affiliate Army Reserve National Guard (ARNG) FA Brigades with AC divisions or Corps for training and deployment; (3) ensure the

Department of the Army Master Priority List (DAMPL) appropriately reflects an increased priority for early deploying ARNG FA Brigades; (4) modernize the early deploying ARNG FA Brigades to ensure interoperability and sustainability with their supported AC counterparts; and (5) increase the CS/CSS force structure within the ARNG, with no change in ARNG end strength, to support the revised FA structure.[12] This study provided an excellent analysis of artillery force structure issues at the macro level and was one of the primary influences in shaping current FA force structure decisions.

TRADOC's Early Entry Force Analysis Final Report prepared by the Fort Leavenworth TRADOC Analysis Center and released in September 1994 provided a good source of data and analysis in regard to early entry force capabilities and limitations. This study addressed the Louisiana Maneuvers 1994 issues of determining how to make light forces more lethal, survivable, tactically mobile, and sustainable and determining the potential contribution to the battlefield by middleweight units, light enough for rapid force projection, yet tactically mobile and lethal.[13] The study evaluated various force packages were and then provided recommendations for improving the designs of the quick response lightweight force and the follow-on middleweight forces. This study provided data on the contribution that several artillery systems made to early entry force lethality and survivability.

Robert H. Scales' Firepower in Limited War provides a historical study of the use of firepower in recent conflicts. Scales provides five case studies taken from post-World War II conflicts: the French-Indochina War, the US involvement in Vietnam, the Soviet intervention in Afghanistan, Britain's Falklands War, and the Persian Gulf War. Scales studies the effectiveness and limitations of firepower given the nature of the conflict, the physical environment, the character of the enemy,

and the types of firepower and specific employment practices. Scales states that a nation should never contemplate involvement in a limited war without a clear understanding of what firepower and technology can and cannot do.[14] Scales shows the problems of an overreliance on the use of firepower to achieve military objectives in limited war. Scales argues that a tactical strategy of attrition through the use of overwhelming firepower is generally inappropriate in wars of insurgency, because the enemy rarely remains in place long enough for effective fires to be brought to bear. Scales argues for a more balanced and integrated combined arms approach to the conduct of limited wars.

Scales' arguments provided much of the foundation for the portion of this thesis that addresses the adequacy of the future artillery for operations across the spectrum of conflict. In his book Scales identifies specific problems that accompanied the use of firepower in limited wars. Among the noted problems were: unresponsive fires, inaccurate fires, ineffective fires, and an excessive reliance on firepower. The thesis examined the specific shortfalls that Scales identifies and looks at the future artillery material, organizations, and operational concepts to determine the effectiveness of the future artillery force in limited wars.

The National Research Council's STAR 21-Strategic Technologies for the twenty-first century is an excellent reference regarding the key technologies identified by the Army for the long-term future. STAR 21 provides a detailed analysis of how the Army can ready itself for the battlefields of the twenty-first century. This book summarizes current developments and emerging technologies with major Army applications in eight areas: (1) Computer Science, Artificial Intelligence, and Robotics; (2) Electronics and Sensors; (3) Biotechnology and

Biochemistry; (4)Advanced Materials; (5) Propulsion and Power; (6) Advanced Manufacturing; and (7) Environmental and Atmospheric Sciences.

The STAR Committee then identified seven focal values to further evaluate the technologies examined above: affordability, reliability and durability, deployability, joint operability, stealth and counterstealth, casualty reduction, and support system cost reduction.[15] The STAR Committee then provides recommendations for developing and integrating appropriate technologies into the Army force structure. The information regarding system applications of advanced technologies and the technological assessments and forecasts were particularly insightful. For the purpose of this thesis I crosswalked the STAR committee's recommendations with the artillery force modernization plan to determine if there were any significant discrepancies.

The FY95 Army Science and Technology Master Plan (ASTMP) was an invaluable reference for analyzing the Army's plan to develop and modernize its forces. The ASTMP details the Army's strategy to apply technology in the design of a well equipped strategic force capable of decisive victory in the uncertain world of the twenty-first century. It provides "top down" guidance from the HQDA to all Army science and technology organizations, and it establishes critical linkages between DOD technology planning and the master plans of individual Army major commands, major subordinate commands, and laboratories.[16] In short, it is the common reference that focuses the efforts of scientists and material and combat developers in support of tomorrow's soldier--it is the road map for developing Force XXI. The ASTMP details the collection of advanced concept technology demonstrations (ACTD), advanced warfighting experiments (AWE) and other technology venues that comprise the Joint Venture axis of the design of Force XXI. The ASTMP allowed a review of

the developmental links between emerging technologies and the future warfighting systems of Force XXI.

CHAPTER 3

RESEARCH DESIGN

> Smaller is not better--more lethal is better; more deployable is better; more sustainable is better; more versatile is better--more effective is better--better is better.[1]
>
> General Gordon Sullivan, Seeing The Elephant

I used a simple, but comprehensive research approach in this thesis. I examined the capabilities and limitations of the future FA force structure to determine if we are building a "better" artillery force for the twenty-first century. A "better" artillery force structure is generally defined as one that is more flexible, capable of operating at an increased tempo, more lethal, and more survivable. This future artillery force must support Force XXI and its patterns of operations. At the same time this artillery force must be capable of decisive operations across the entire spectrum of conflict, while avoiding technological obsolescence during a period of dramatic change. These are the most critical force structure challenges facing the future artillery. These are the things the artillery must get right if it is to retain the title of King of Battle during the twenty-first century.

The overall research design is graphically depicted in figure 3. Research issue one is the primary topic of this thesis and the bulk of the analytical effort is focused on this issue. Research issues two and three are intended to be supplementary. These issues complement the primary issue by examining the future artillery force structure in the

context of two additional areas of major operational consequence for the twenty-first century.

The research design explored the thesis topic through an analysis of the material systems, organizational structures and operational concepts of the future FA force to determine if we are building an artillery force optimized for the many challenges of the twenty-first century. This research design allowed for consideration of quantitative and qualitative data in the analysis of these issues. The data came from a wide variety of sources. Especially valuable sources were several recent Army Science Board studies, the series of PW/MSF AWEs, and the many studies and analyses supporting the development and acquisition of new artillery systems and munitions. This research design allowed for both subjective and objective analysis of the issues.

The primary research issue was to determine if the future artillery force structure will support Force XXI operations. The research design for this issue focused on an examination of the Force XXI patterns of operations described in chapter 2. These patterns of operations are the operational tasks that Force XXI and its artillery component must perform. These patterns of operations became the yardstick by which I evaluated the capability of the artillery to support the future force. The ability of the future artillery force structure to support each pattern of operation is treated as a subordinate research issue, which provided a detailed analytical structure for examining the most operationally critical aspects of the future FA force structure. Figure 4 depicts the research design for the primary research question.

I then examined each pattern of operation in greater detail to determine if the future FA force structure – its material systems, organizations and operational concepts – supports Force XXI operations. This required identification of specific artillery material functions and

capabilities, organizational structures and operational concepts that would support the execution of a given pattern of operation. There is not a lot of written guidance for translating the patterns of operation into specific tasks and functions. My efforts at characterizing and categorizing these future artillery initiatives in terms of Force XXI patterns of operation is not intended to be definitive. Sometimes the distinctions between operational patterns can become vague. For example, the pattern of gaining information dominance is also a means of shaping the battlespace and could even be considered the decisive operation of the conflict.

Also, a given artillery capability, organization or operational concept may support several operational patterns. For example, the artillery capability to maneuver could be considered as supporting the pattern of force protection, or enhancing the ability to shape the battlespace, or even enabling the ability to conduct decisive operations. The artillery Deep Operations Coordination Cell (DOCC) can support the pattern of force protection, gaining information dominance, enhance the ability to shape the battlespace, or even enable the ability to conduct decisive operations. Emerging TTPs such as sensor to shooter and joint precision strike are similarly flexible, supporting many of the patterns of operations.

The research design evaluated each pattern of operation independently and considered the effects of a given artillery system, organization, and operational concept in the context of that specific operational pattern. If the force structure initiative made a strong contribution to supporting a pattern of operation it was analyzed and discussed in relation to that specific pattern. This methodology allowed for a comprehensive and organized approach to examining this complex issue.

The analysis of the operational pattern project the force evaluates the ability of the future artillery force to deploy strategically. The intent is to determine if the future FA force structure supports power projection operations. This issue centers around the amount of strategic lift required to deploy the future artillery. In this case, smaller is better, or more specifically smaller, lighter and modular is better. This issue could be evaluated objectively using comparative analysis. It is possible to quantify and compare individual system weights and measures, gross unit movement characteristics, and the amount of strategic lift required for deployment. The ability of the FA force to be rapidly tailored for contingency operations is a function of the modularity of the force structure. Modular force design allows detaching functions and capabilities from a parent unit and tailoring such functions and capabilities for deployment in support of a power projection operations. Modular design seeks to optimize unit capabilities and strategic lift.

The analysis of the operational pattern protect the force evaluates the contribution the future artillery will make to the ability of Force XXI to survive on the future battlefield.

This issue addresses the ability of the FA force to provide protection to the rest of the force, as well as its own ability to survive enemy attack. This issue could be evaluated objectively because force and system survivability can be quantified using data from approved and accredited combat development computer models. The primary measure of effectiveness for this issue is the Loss Exchange Ratio (LER). A LER is an aggregate measure of the number of friendly combat systems losses versus enemy combat systems losses (Red combat systems losses divided by blue combat system losses). Combat system losses are generally defined as the total number of tanks, armored fighting vehicles, artillery pieces

and helicopters killed. The FA force structure that enables a higher force LER provides better force protection. The FA force structure that achieves a higher field artillery exchange ratio (AER) is more survivable. The AER is generally defined as the number of enemy cannon and rocket system losses divided by friendly cannon and rocket system losses. Also, the contribution of the FA force structure to Force XXI early entry survivability and lethality is examined under this pattern of operation, because the survivability of early entry forces is fundamentally a force protection issue.

The analysis of the operational pattern--gain information dominance--evaluates the contribution the future artillery will make to the ability of Force XXI to conduct and dominate information operations. The evaluation of this issue is primarily a subjective analysis of the contribution to information operations made by the material systems, organizational structure, and operational concepts of the future artillery. Information dominance is best expressed as the difference between the friendly force's ability to acquire, share and use information and the ability of the enemy force to do same. In order to achieve information dominance a force must pursue two complementary axes: friendly forces must maximize their ability to use information, while simultaneously degrading the enemy's ability.

The artillery contribution to maximizing friendly information operations is a function of its capability to acquire, integrate, and use information both vertically and horizontally. Vertical integration refers to the ability to acquire, share and use information internally within the FA BOS stovepipe. Horizontal integration refers to the ability of the artillery to acquire, share and use information externally across the force, to coordinate and synchronize with the other BOS. The artillery contribution to minimizing the enemy force's ability to conduct

information operations is a function of its ability to use lethal and nonlethal methods of attack against the enemy information network.

The analysis of the operational pattern--shape the battlespace--evaluates the contribution the future artillery will make to the ability of Force XXI to set the conditions for decisive operations. This issue requires both subjective and objective analysis in order to evaluate the contribution of future artillery material systems, organizations, and operational concepts to shaping the battlespace. Shaping the battlespace is a complex concept that is difficult to quantify or qualify with any degree of specificity. Force XXI efforts at shaping battlespace will be situationally dependent on the factors of METT-T. However, all actions taken to shape battlespace will require the capability to span the battlefield dimensions (physical, mental, and temporal) and effect some specific enemy function or formation. This implies the ability to reach out and touch something. This in turn implies the capability to cover the battlespace using a combination of fire and maneuver. The artillery's capability to perform these functions can be quantified. The function of battlespace coverage examines the amount of battlespace the FA force can directly shape by examining the capabilities of the weapons in terms of their range, accuracy and responsiveness. The capability of the future artillery to conduct tactical maneuver contributes directly to shaping the battlespace by allowing the commander to rapidly shift his artillery about the battlefield and to place high volumes of fire into areas previously thought to be safe from artillery attack. This portion of the analysis will also examine the contribution to shaping the battlespace made by the Deep Operations Coordination Cell (DOCC) and selected artillery TTPs.

The analysis of the operational pattern--conduct decisive operations--evaluates the contribution the future artillery will make to

the ability of Force XXI to conduct decisive operations. The ability to fight with fires is central to the Force XXI concept of decisive operations. Analysis of this issue centers on the lethality of the FA force and its capability to fight with fires. The conduct of decisive operations encompasses the traditional roles of the artillery: close support fires, counterfires, and interdiction fires. The ability to support decisive operations requires the capability to deliver massed concentrations of highly lethal fires quickly over wide frontages and out to great depths. It also requires the capability to displace rapidly, keep pace with the maneuver arms, and maintain a high rate of operational tempo. Decisive operations also requires the ability to surge and deliver concentrated pulses of firepower to shock and break the enemy's will to fight. This issue could be evaluated objectively because it is possible to quantify the contribution of the MSF artillery to overall force lethality. It is also possible to examine other tactical functions and performance characteristics that enable the FA to deliver decisive fires. This portion of the analysis examines the effects of proposed artillery organizations and operational concepts on the ability of Force XXI to conduct decisive operations.

The analysis of the operational pattern--sustain and transition--evaluates the contribution the future artillery will make to the ability of Force XXI to sustain and transition. The analysis of this issues focuses on the sustainment requirements of the future artillery force. This pattern of operation can be evaluated through a comparison of the projected force support requirements. In the case of sustainment requirements, less is more. The artillery force that requires the least amount of combat service support to sustain is better. This portion of the evaluation is highly speculative and is based entirely on current design requirements and performance specifications.

The research designs for the supplementary research issues are not as structured as was for the primary research issue, nor are they intended to be as comprehensive. The intent is to conduct a broad brush analysis designed to surface major issues that may have significant operational implications if not considered.

The international security environment of the twenty-first century will span the entire spectrum of conflict, but operations at the low end of the spectrum are likely to be most common. The research methodology for evaluating the suitability of the future FA force structure for operations across the spectrum of conflict uses the analysis from the primary research issue, and additional analysis based on examination of historical and contemporary uses of field artillery in low intensity conflict and MOOTW. The research design focuses on an evaluation of the capabilities and limitations of the artillery in LIC/MOOTW. I relied heavily on Lieutenant Colonel Robert Scale's Firepower in Limited War, recent Combat Training Center (CTC) and Combined Arms Lessons Learned (CALL) publications, and FM 100-20, Military Operations in Low Intensity Conflict, to develop the research design for this issue.

The analysis consists of an evaluation of the contribution the future artillery will make to the ability of Force XXI to operate in LIC/MOOTW. In these settings restrictive rules of engagement are the norm and the avoidance of collateral damage and casualties is often paramount. Conventional artillery capabilities, such as the ability to attack enemy formations at depth, the ability to rapidly shift and mass fires, and to cover large areas with volumes of lethal fires are of limited tactical value in LIC/MOOTW. In LIC/MOOTW environments other capabilities become more desirable, such as increased responsiveness and precision. Some specific criticisms of the artillery in LIC/MOOTW

scenarios are that it is of little utility, too slow, too big, too destructive, too much. Some have even gone so far as to suggest that if the artillery fails to adapt to these new conditions that the profession could simply "go away."[2]

The research design for evaluating the appropriate application of technology to the future FA force is structured to accomplish two objectives: identify areas of technology that may be excessively risky; and to identify emerging or potential applications that may have been overlooked. The research design for this issue is subjective and is based on a review of current defense and technology related sources to determine if the future FA force structure has a sound technological base and can integrate needed technologies that will provide operational solutions by the year 2010. A detailed consideration of cost factors associated with the development of a potential technology application exceeds the scope of this thesis.

CHAPTER 4

ANALYSIS

General

This chapter is structured in accordance with the research design outlined in chapter 3. This framework enabled the use of a combination of analytical techniques in answering the primary and secondary research questions: (1) use of military judgment to evaluate subjective issues, (2) use of comparative analysis to evaluate objective issues, (3) use of modeling/simulation data to evaluate force effectiveness issues, and (4) review of assumptions made in force structure analyses and decision process. No single analytical technique was considered more authoritative than another. The use of a combination of analytical techniques allowed for a thorough examination of the available data.

The artillery systems and organizations shown in the following figures and tables depict the future force structure design analyzed in this thesis. The division artillery (DIVARTY) and FA Brigade artillery force structures shown in figure 6 and table 1 include the most current artillery force design initiatives. Major General Randall Rigby, Commandant of the United States Army Field Artillery Center and School, provided a recent briefing (6 March 1996) to Command and Graduate Staff College (CGSC) students on the changing field artillery force. In this briefing Major General Rigby presented many of the specifics of the future DIVARTY and FA Brigade design. For the purpose of this thesis I assumed the future artillery force structure would be as presented in this briefing.

The briefing disclosed the recent Army decisions to restructure heavy cannon battalions under the 3x6 configuration, to add an additional battery of MLRS to the heavy DIVARTY, and to change the allocation rule of one FA Brigade per committed division to two. The briefing also revealed there were no changes planned to the light DIVARTY force structure in the Force XXI design process.[1] The final decisions on the exact composition and structure of artillery force structure in support of the light divisions are still pending the results of the DA directed Legal Mix VIII study. For the purpose of this thesis I considered the light DIVARTY force structure to be unchanged, as was stated in Major General Rigby's briefing. For the purpose of this thesis I assumed that light divisions would receive the same amount of additional artillery support as a heavy division. I used the Army Science Board's recommendation of two FA brigades per committed division and postulated that the light FA brigades would be structured similarly to the heavy FA brigades, except they would have light versions of the 155mm cannon and MLRS systems.

The future artillery force structure reflects the impetuses of modern technology, organizational restructuring, and new operational concepts. Shown in figure 5 are the major force developments and initiatives that will shape and define the artillery force of 2010. These are the material systems, organizations, and operational concepts that translate the philosophy of Vision 2020 into the reality of force structure design.

Current Force XXI design efforts are focused at the division level. The maneuver division remains the central element of landpower, providing the means to fight and win, to assert control, and to achieve decisive victory.[2] Accordingly, this thesis examines the future artillery force structure that will be in support of a maneuver division. Shown below is

a graphic depiction of the current and future artillery force structures assigned to and supporting a committed maneuver division. The heavy division artillery (DIVARTY) structure is representative of the artillery force structure in all armor and mechanized infantry divisions. The airborne DIVARTY structure is representative of the artillery force structure in the light forces, and has additional significance as the Army's primary early entry force. Figure 6 shows the artillery force structure under the current AOE design and the most current version of the future Force XXI design.

Shown in table 1 are the specific types and numbers of artillery weapons systems that will be in support of a committed maneuver division under the current and Force XXI force structures. The table provides a "tube count" for the organizations shown in figure 6 on the previous page. This table is provided as a quick and simple point of reference for purposes of comparative analysis. It is evident that the Force XXI force structure significantly increases the total number of artillery weapons systems firing in support of the division.

In the case of how much artillery is enough, most combat veterans will tell you that more is always better. The tube count on the previous page shows that the future artillery force will be better than the current. Especially significant is the increased number of rocket systems in support of the division. The number of Multiple Launch Rocket Systems (MLRS) supporting a heavy division will double, from 63 to 126. The number of rocket systems in support of a light division quadruples, from 27 MLRS to 128 High Mobility Artillery Rocket System (HIMARS). The number of cannon systems supporting the heavy division remains essentially constant, from 96 to 90. The light division will have fewer cannon systems in general support (from 72 to 36), but this is offset by the increased number of rocket systems.

The future artillery force will provide significantly more artillery support to a committed maneuver division, but the increase in artillery assets is all external to the division. The numbers of artillery systems organic to the division is reduced in the heavy DIVARTY and remains unchanged in the light DIVARTY. The reason for the increased amount of artillery support to a maneuver division is the allocation of an additional FA brigades. While more artillery is always better, this arrangement makes the division's combat power more dependent on augmentation from echelon above division (EAD) assets.

Project The Force

My analysis of the Force XXI FA force structure in relation to the operational pattern--project the force--examined the issue from both the individual systems level and the aggregate force level. The weapons systems that will define the FA units and the units that comprise the Force XXI artillery force structure were examined to see how well this future force structure enables power projection operations. The results are something of a mixed bag. Some systems are heavier/less transportable and others are lighter/more transportable than the current systems. Some units are heavier/less deployable and others are lighter/more deployable than the current units. As a whole the Force XXI artillery force structure is no more strategically deployable than the current force structure.

Shown below in table 2 are the specific weights and measures of the primary weapons systems of the current and future FA force structure. Data was extracted from the Jane's Armor and Artillery 1995-96. Figures for the developmental systems are either taken from prototypes, or are engineering estimates. The data is provided so that simple comparative analysis regarding system size and transportability can be done.

The Crusader is much heavier and larger than the Paladin it replaces. With a projected weight of 55 tons, Crusader's air transportability is the equivalent of the M1 Abrams main battle tank. Each system is an outsize load, which requires either a C-17 or C-5 to be air lifted. However, strategic mobility is not operationally degraded relative to the status quo, because the systems it will replace, the Paladin and M109 series howitzers, are not air transportable on anything smaller than a C-17. Strategic deployment by sea lift is essentially unaffected. The dimensions of the Crusader are not significantly greater than the Paladin it replaces, and strategic sea lift assets would be able to accommodate the increased size and weight. Although Crusader is larger and heavier than the Paladin, this does not translate to a corresponding decrease in strategic mobility.

The 155mm Advanced Towed Cannon Artillery System (ATCAS) will be much lighter than M198, but this reduction in weight will provide only slight improvement in terms of strategic mobility. The weapon and its associated prime mover still requires approximately the same amount of cubic space to deploy. So, even though the ATCAS is lighter than the M198 this does not significantly lessen the strategic lift requirement. An ATCAS Battalion would require the same amount of C-17 sorties as an M198 battalion (36).[3] ATCAS would require slightly fewer sorties if deployed using a combination of C-130/C-141 or C-141/C-17 aircraft.[4] ATCAS would be larger and heavier than the 105mm M119 towed howitzer. The ATCAS Bn would be less deployable than an M119 battalion, requiring an additional 11 C-17 sorties (36 versus 25).[5]

HIMARS is a true "silver bullet" weapon system for a power projection army. The HIMARS is smaller and lighter than an MLRS and is air transportable in a C-130. Compared to the number of strategic air lift assets required to deliver MLRS units to the theater of operations,

transporting a comparable number of HIMARS units saves 25-30 percent of the strategic lift.[6] HIMARS provides the commander an immediately responsive, roll-on roll-off deep attack weapon system. HIMARS is capable of firing the entire MFOM to the same ranges and with the same precision as the MLRS.

The recent decision to restructure the 155mm cannon battalions in the 3x6 configuration reduces the number of oversized and outsized cargo loads in the battalion by a total of twelve systems (six howitzers, and six support vehicle/prime movers). This will enable heavy cannon battalions to close sooner. However, this decision is so recent that I was not able to get strategic movement data for 155mm cannon battalions reorganized under the 3x6 configuration and determine the amount of improvement this will make in terms of strategic movement.

Comparison of the Force XXI FA force structure to the existing force structure shows that it is only marginally "better" in terms of strategic air movement. The improvement is due to a combination of system design and organizational restructuring. Smaller and lighter systems, such as HIMARS and ATCAS, provide improved strategic mobility. However, the Crusader is not smaller and lighter. Strategic air mobility is improved by restructuring the heavy cannon battalions under the 3x6 configuration, decreasing the number of self-propelled cannons and ammunition support vehicles in a heavy cannon battalion by 75 percent, from 48 to 36. This is a significant finding, particularly in the event of a contingency operation that would require power projection of heavy forces into a nonlittoral region.

Comparison of the Force XXI FA force structure to the existing force structure shows that it is not more strategically mobile in terms of sealift requirements. Smaller artillery systems and smaller units weigh less and take up less space, but strategic movement by sea is not

as sensitive to the specifics of system design as is air movement. In relation to typical sea lift assets the gross unit movement characteristics are essentially unchanged. Sea lift assets are able to accommodate substantial increases in cargo weight and cube. The usual planning figure for cargo stowage on typical sealift assets is only 75 percent of capacity.[7] Sea lift assets could easily accommodate the relatively minor increase in cargo load that the Crusader system would cause. The restructuring of heavy cannon battalions under the 3x6 configuration does not provide any significant improvement in terms of the strategic sea mobility of the future artillery force.

Modularity

Modular force design provides force elements that are interchangeable, expandable, and tailorable to meet changing mission needs. The ability to package specific force elements allows maximizing of appropriate force requirements and optimized use of strategic lift. Specific force elements can be projected to meet the minimum needs of the contingency operation, while leaving the non-essential elements at the home station. This technique of force design also facilitates the common practice of task organizing units on a short term, ad hoc basis to accomplish specific tactical missions.

Force XXI artillery battalions are modular designed elements, which means they are constructed with subordinate elements having specific capabilities. Each subordinate element (the Headquarters and Headquarters Battery, the Firing Batteries, and the Service Battery, or a combined Headquarters and Service Battery) has the personnel and equipment to perform only selected tasks and functions. Each subordinate elements is a discrete part of the organizational whole and they must be combined to provide the entire functional capability of the unit.

During PW/AWE 1994 the Mobile Strike Group's direct support artillery units were organized as composite battalions (two Crusader 155mm self-propelled batteries, and one ATCAS 155mm towed battery). This organization of a composite cannon battalion is a valid method to increase the flexibility and modularity of the FA force structure. A composite cannon battalion could increase the options available in designing and deploying specific force packages for contingency operations. The ATCAS firing battery could be detached from the parent battalion and placed separately into the deployment sequence to provide an earlier force protection capability. However, this organizational method was not pursued in subsequent experiments. I was unable to determine why this organizational concept was abandoned. I can only assume that the tactical disadvantages outweighed whatever advantages were achieved.

Protect The Force

My analysis of the Force XXI FA force structure in relation to the operational pattern--protect the force--examined the issue from the aggregate force and individual systems levels. The findings were unequivocal. Every single FA force structure initiative and force development provides improved force protection: (1) Paladin protects the force better than M109; (2) Crusader protects the force better than Paladin; (3) ATCAS protects the force better than the M198; (4) M270A1 protects the force better than the M270; (5) Precision guided munitions protect the force better; and (6) 2 FA brigades supporting DIVARTY protects the force better.

Each of these force developments provides a significant increase in force protection. The effect of all of these force structure initiatives when taken together promises to be revolutionary. I was not

able to quantify the overall contribution that the Force XXI FA would make to protecting the force, but the data from each of the separate programs and initiatives is conclusive.

Force XXI artillery provides better protection to the force, and is more survivable itself. The increase in force protection is directly attributable to the increased lethality of the FA force (best defense is a good offense) and the improved survivability of the individual weapons systems. The increased lethality of the systems is synergistic, allowing for the rapid and effective destruction of enemy forces before they have the opportunity to attack friendly combat systems. This considerably improves the force on force loss exchange ratios (LER) in favor of the friendly force, because the increased rate and number of enemy combat system losses over time means these systems are not able to destroy friendly combat systems. Simply put, the Force XXI FA provides force protection by killing enemy combat systems before they kill friendly forces.

Most of the future artillery systems and/or initiatives examined in this thesis were evaluated in separate DA approved studies or analysis and found to improve force loss exchange ratios (LER). The contribution that each of these artillery systems and initiatives made to force LERs was measured and determined relative to a base case without that system or initiative. This means that it is possible to illustrate the separate and unique contribution to force protection that each of these artillery systems and initiatives provides. Figure 7 provides a graphic illustration of the improvement to force loss exchange ratios that future artillery systems and initiatives will provide.

Each measure on the bar graph illustrates the average amount of improvement in force loss exchange ratios that the system or initiative provided. The measure titled Paladin represents the improvement to force

LERs made by the Paladin howitzer relative to a force equipped with the M109 series howitzers. The measure titled Crusader represents the improvement to force LERs made by the Crusader howitzer relative to a force equipped with the Paladin howitzer. The measure titled tactical precision guided munitions (PGM) represents the improvement to force LERs made by short-range (less than 100 km) smart munitions, such as the Sense and Destroy Armor Munition (SADARM) and MLRS Smart Tactical Rocket (MSTAR) relative to a force without tactical PGMs. The measure titled operational precision-guided munitions (PGMs) represents the improvement to force LERs made by long-range (greater than 100 km) smart munitions, such as the ATACMS Block II/IIA missiles relative to a force without operational PGMs. The measure titled 2 FA Bdes GSR represents the improvement to force LERs made by increasing the number of FA brigades in support of a division from one to two.

The data for this figure was taken from a number of sources. Each of these artillery systems and initiatives was evaluated in a variety of combat scenarios; to include brigade, division, and corps level offensive and defensive operations in NEA, SWA, and European environments. Each scenario resulted in a different measure of force LERs. I aggregated the results to keep the hart simple. The chart is intended to provide the reader with an overall picture of the contribution to force protection that the future FA will provide. It can be seen that the increased amount of artillery and improved weapons platforms and munitions of the Force XXI FA will protect the force better.

The increased survivability of the total force is mirrored by improved artillery survivability. Better weapons systems combine with new organizational and operational techniques to make Force XXI artillery more lethal and more survivable. This adds up to fewer losses of

friendly FA systems relative to enemy FA systems losses. This measure of effectiveness is referred to as the artillery exchange ratio (AER).

The use of such organizational and operational concepts as split-battery operations and "shoot and scoot" tactics combines with improved tactical mobility to almost entirely negate the effects of enemy counterfire against friendly self-propelled cannon and rocket units. These techniques, combined with the increased lethality provided by improved weaponry and munitions will make the future artillery better able to survive in even the most hostile combat environments.

The most significant factor in the improved artillery survivability is the practice of shoot and scoot tactics. Shoot and scoot refers to the technique of pairing howitzers in groups of two and conducting short (500 to 1000 meters) "survivability" moves immediately after the completion of a fire mission. Enemy counterfire falls on the empty firing position, while the howitzers move to and occupy a new firing position and continue to provide fires. The exact distances and frequencies of the survivability moves are situationally dependent based on the mission and an evaluation of the threat counterfire capability.

The ability to use shoot and scoot tactics is dependent on the capability to rapidly displace, move cross country, occupy a new firing position, and establish a firing capability within a couple of minutes. Not until the fielding of the Paladin howitzer did the cannon artillery have such a capability. Prior to Paladin, a cannon unit occupying a firing position had to execute a complex series of actions to select, prepare, and occupy the firing position. Before a unit could provide fire, the howitzers had to be brought into position, oriented on the azimuth of fire, laid for direction, and then each individual weapon's location determined and reported to the controlling Fire Direction Center (FDC). These actions were manpower intensive and time consuming. A

particularly time consuming and critical step in this process was establishing and transferring common position location and directional control to each howitzer.

With the advent of the Paladin and Crusader systems, this complex series of actions has been almost entirely eliminated. Both systems feature an integrated onboard position and navigation (POSNAV) system that allows the howitzer to quickly and accurately determine its own location and then lay for direction. Both systems have an automated fire control system (AFCS) that calculates weapons firing data on board the howitzer. Both systems have on board radios to provide enhanced responsiveness and tactical command and control (C2). Both systems can communicate with their fire direction centers over digital links, eliminating the need to lay wire communications lines. The Crusader is able to establish direct, digital sensor to shooter links between itself and an IVIS (Inter-Vehicular Information System) equipped Abrams tank.

The effect of shoot and scoot tactics to improving loss exchange rates is illustrated by the Paladin measure in figure 7. The use of shoot and scoot tactics allowed Paladin to survive better, which enabled the artillery to kill more enemy systems, and more friendly systems to survive. The reason for Paladin's dramatic improvement in force LER is the initial gain in survivability that shoot and scoot tactics provides. This makes it appear that Paladin contributes more to improving force effectiveness than does Crusader. It is should be noted that the Paladin figure is relative to an M109 equipped force and the Crusader figure is relative to a force equipped with the Paladin.

The effects of improved tactical mobility on cannon survivability are extremely significant. The charts in figure 8 illustrate the effects that improved tactical mobility, specifically a faster cross country dash speed has on system survivability. The chart on the left shows the

effects of limiting Crusader's dash speed to the same level as the Paladin, by increasing the amount of time required to execute a survivability move. It can be seen that if the Crusader's dash speed is made equal to that of the Paladin that an equal number of systems are lost. The chart on the right shows the effects of increasing the dash speed of the Paladin to the same level of the Crusader (technically not possible). It can be seen that setting dash speed of the Paladin equal to the Crusader reduces the number of cannon system losses. In both cases the benefits of increased tactical mobility are clear. Improved tactical mobility allows the cannon to move farther and faster from the firing point. The ability to conduct rapid, cross country dashes cuts cannon losses almost in half. A faster artillery force is more survivable, a faster artillery is better.

Crusader promises to be an extraordinarily survivable system. Crusader will have an improved capability to use shoot and scoot tactics. Crusader will have better on board self location and orientation systems and capabilities. Crusader will have a GPS based navigation system that is more accurate than the inertial reference system on the Paladin, and that requires no updating at survey control points. Crusader will have better tactical mobility than the Paladin, providing even greater survivability. Crusader will have 1500 horsepower compared to the 440 horsepower of the Paladin. The increased horsepower will enable Crusader to move faster than Paladin to escape the effects of enemy fires. Crusader's improved armor protection will increase system survivability when the effects of enemy fire cannot be avoided. Crusader is required to provide a smart munitions countermeasure system and ballistic protection against the effects of DPICM. Paladin provides no capability to counter smart munitions, and only limited ballistic protection against the effects of fragmentation. Figure 9 below shows that Crusader will

improve artillery exchange by more than 75 percent in both the SWA and NEA scenarios.

The self-propelled cannon force is not the only portion of the future FA force structure with improved survivability. The M270A1 launcher with Improved Fire Control System (IFCS) and Improved Launcher Mechanical System (ILMS) modifications reduces exposure time on the firing point by 75 percent, and reload time is reduced by 30 percent. The launcher is able to complete fire missions faster, stow the loader launcher module (LLM) more quickly and depart the firing point. There is no computer modeling data to provide quantitative data regarding the increased survivability of the M270A1, because no COEA was required for the IFCS and ILMS upgrades. However, it seems evident that reducing the time spent in these activities reduces the vulnerability of the system.

The ATCAS will provide improved survivability by reducing the amount of time needed to emplace and displace the system. The operational requirement for the ATCAS is the ability to emplace within three minutes or less, and displace within less than two minutes. The ability to "engage and evade" and make up to four survivability moves an hour will provide enhanced survivability. Figure 10 below shows the improved survivability of the ATCAS relative to the M198 howitzer in the light division defense of lodgment SWA scenario.

Unfortunately, technology has yet to bring a true shoot and scoot capability to towed howitzers. Some towed howitzers feature an auxiliary propulsion unit (APU) that allows the system to move independently of the prime mover. While not providing a significant advantage in terms of tactical mobility, such systems would provide improved tactical mobility and enhanced capability to engage and evade. However, the addition of an APU would probably increase the weight of the system beyond the allowed ceiling of 9,000 pounds.

Early Entry Lethality and Survivability

The survivability of our early entry forces (EEF) is a particularly critical challenge facing Force XXI designers. As the spearhead of any likely power projection operation, the survivability of our EEF is an issue that should command the fullest attention of our combat developers. Early entry is the most critical phase of any operation. It is during this phase that U.S. forces are most vulnerable to attack and face the greatest risk of defeat: they can be denied entry, they can be overrun and they can lose.[8] Any enemy that "went to school" on the lessons of Operation Desert Storm is likely to take action to deny U.S. forces the ability to build up and achieve superiority, inflict casualties early, and deny U.S. situational awareness.[9]

Current early entry forces remain extremely vulnerable to a wide variety of threats until the arrival of the heavy forces. The most significant threats facing the EEF are tactical missiles, port/airfield attacks, and mechanized armor and artillery forces. The EEF have a limited capability to employ fire and maneuver to respond to these threats. EEF are particularly vulnerable to attack by enemy mortars and artillery during the first days of the lodgment. The Army Science Board was extremely concerned about the threat that these standoff weapons posed to the EEF, stating there appeared to be no effective response to this threat, and that as yet it was not apparent that an urgent program to remedy this deficiency had been put in place.[10]

The Army Science Board concluded that the critical focus of a power projection army must be on strategic lift and increasing the capabilities of the EEF. The ASB recommended the Army pursue several capabilities in the near term to reduce the vulnerability of the EEF in the early phases of a power projection operation. The specific capabilities recommended were: (1) the massive suppression and

exploitation of the enemy information warfare capability; (2) defense against the proliferated missile threat; and (3) extended range counterbattery and antiarmor capabilities.[11]

The future artillery can provide the EEF an improved capability in all of these areas. The ongoing Rapid Force Projection Initiative (RFPI) has found that an information-dominant force equipped with an advanced fire support system can generate overwhelming combat power from the opening moments of military operations.[12] The increased lethality and standoff capability that strategically mobile systems artillery systems such as HIMARS and ATCAS provide to light forces are significant combat multipliers. ATCAS and HIMARS can give the EEF the capability to attack the enemy's C4I network, to conduct counterbattery fires against all types of indirect fire systems, including ballistic missiles, and the ability to expand the battlespace.

These systems provide the ability to attack enemy forces with precision guided munitions at extended ranges, reducing the intensity of any subsequent close combat. The ability to attack forces in depth allows the EEF to delay, disrupt and destroy enemy forces on terms more favorable than the close fight. HIMARS with its ability to deliver large quantities of improved conventional munitions, the "steel rain" so dreaded by the Iraqis, can engage the enemy at depth, break the momentum of an enemy attack, suppress artillery systems, and set the conditions for friendly maneuver. ATCAS gives the EEF increased lethality by delivery of the 155mm family of munitions (DPICM, FSCAM, SADARM, and Copperhead). The tactical value of the extended range and lethality that the artillery provides in an early entry scenario is shown in Figure 11.

In this scenario the addition of a single MLRS battery and a total of 40 ATACMS Block II missiles improved the EEF loss exchange ratios by 50 percent. The improved capability that the future artillery

will provide the EEF to degrade the enemy's command and control capability, provide counterfires, and extend the battlefield will be examined in greater detail in later sections.

Gain Information Dominance

> The high ground is information. Today, we organize the division around killing systems, feeding the guns. Force XXI must be organized around information - the creation and sharing of knowledge followed by unified action based on that knowledge which will allow commanders to apply power effectively.[13]
>
> General Gordon Sullivan,

My analysis of the Force XXI FA force structure in relation to the operational pattern--gain information dominance--examined the issue at the aggregate force level. I examined the emerging doctrine, material, and tactics, techniques and procedures (TTPs) to determine if the Force XXI field artillery supports gaining information dominance.

Information dominance is best expressed as the difference between the friendly force's ability to acquire, share and use information and the ability of the enemy force to do same. In order to achieve information dominance a force must pursue two complementary axes: friendly forces must maximize their ability to use information, while simultaneously taking action to degrade the enemy's ability. The ability to use information better than your opponent is emerging as a distinct and critical aspect of combat power.

Information dominance directly enables the ability of Force XXI to "fight with fires." Force XXI FA units are designed to do the bulk of their killing through delivery of operational and tactical fires of unmatched lethality at greatly extended ranges. Force XXI forces will engage and defeat much larger threat forces by virtue of this capability to deliver massive volumes of precision-guided munitions at high payoff targets at critical junctures in time and space. This ability to execute deep and simultaneous attack is dependent on a complex coordination of

sensors and shooters in time, space, and purpose. This in turn requires the ability to collect, share and use a tremendous amount of information. The future FA must be able to rapidly and accurately pass information horizontally across the force, and vertically within the BOS.

Real-time situational awareness of friendly and enemy forces is a fundamental component of information dominance. The timely and accurate flow of information regarding the enemy's identity, location, strength, and activity enables Force XXI units to effectively engage threat functions and formations when and where the commander has decided to impose his will. This type of information is critical to shaping the battlespace and the conduct of decisive operations. The future artillery has the automated links and digital systems that will enable this capability.

It is not the intent of this thesis to examine the specific sensors, target acquisition devices, and the fire control devices that will provide the future artillery's information operations capability. The future artillery is fully plugged in to the Force XXI integrated battlefield targeting architecture (IBTA) through such automated data processing devices as the Advanced Field Artillery Tactical Data System (AFATDS). The field artillery is linked with the corps and division Analysis Collection Element (ACE) and able to draw on the capabilities of the All Source Analysis System (ASAS). Basis of issue plans for the common ground station (CGS) include one for each maneuver brigade and one for the DIVARTY, which will provide the artillery the ability to tap directly into Joint Surveillance Target Attack Radar System (JSTARS) and Unmanned Aerial Vehicles (UAV) downlinks. These systems will significantly increase the flow of targeting data and reduce mission processing times.

The ability to operate within the enemy force's decision cycle is another critical component of information dominance. It is of little value to have near perfect knowledge of the enemy if friendly action based on this knowledge is reactive, rather than proactive. The intent is to use battlefield knowledge to dictate the terms of engagement, creating a pattern of cascading effects that increasingly degrades the enemy ability to take effective action. A proactive approach to information operations is critical to the ability to gain information dominance.

The artillery has developed a doctrine that focuses its information efforts internally and externally with respect to the enemy. Targeting is the doctrinal process of identifying enemy targets for possible engagement and determining the appropriate attack system to be used to capture, destroy, degrade, or neutralize the target in question. This targeting methodology is frequently referred to as the D3A cycle. The *decide* phase establishes what parts of the enemy force the commander wants attacked, the priority of attack, the effects desired, the preferred attack means, and the general location. In the *detect* phase sensors are oriented to acquire the specified targets so that they can be engaged. Then the friendly force must *deliver* the means to achieve the desired effects. Lastly, the friendly force must *assess* the results of its attack to determine if the desired results were achieved, which is then fed back into the decide phase. The D3A cycle is an ongoing process repeated continuously throughout the operation.

It can be seen that the targeting methodology described by the D3A process is an important procedural step in gaining information dominance. It maximizes the friendly capability to create and share information by focusing and synchronizing the entire organization's efforts. Tasks and responsibilities are clearly established. Specific

information requirements are determined and prioritized, collection assets are allocated, and units are readied to act on receipt of the information. In BCTP after action reports this focusing and synchronization of friendly information operations is often identified as the key to mission success.

The targeting process also works externally to degrade the enemy ability to perform information operations. The commander can decide to specifically target the enemy's information and reconnaissance, surveillance, and target acquisition (RSTA) systems. Future commanders may best shape the battlespace for decisive operations by attacking the enemy's battle management systems, data networks, intelligence/RSTA means, and C2 nodes. The targeting process can then be seen as an essential and synergistic method for linking the commander's concept for defeating the enemy on the one hand, and the synchronization of his combat power on the other.

Doctrine must be supported with material systems and tactics, techniques and procedures to enable execution on the battlefield. The artillery is currently fielding a new automated fire control system, AFATDS that will tremendously improve the ability to share and use information across command and control, and fire support, and intelligence systems. This is an extremely complex and time consuming activity involving the performance of almost 500 separate fire support functional tasks. These tasks are grouped into 27 functions covering five major categories: fire support planning and execution, movement control, field artillery mission support, and fire direction. AFATDS will fully automate this process, as compared to TACFIRE which only performed 147 of these tasks, speeding the time between acquisition and attack of targets.

Fire mission processing (tactical and technical fire direction) is fully automated, using screens and filters to ensure the attack of targets in accordance with the maneuver commander's guidance. Incoming mission requests are checked against fire support coordination measures and unit zones of responsibility to reduce the potential for fratricide. If a violation occurs, AFATDS notifies the operator and electronically requests clearance from the unit that established the control measure. AFATDS also provides an immediate situational awareness (specific to the fire support BOS) of the battlespace. Friendly and enemy unit locations, target overlays, battlefield geometry, FSCMs, and unit logistics status can be selectively displayed using up to seven separate overlays.

An examination of current and developing weapons and munitions reveals an increasingly capable arsenal of lethal and non-lethal means that can be directed against the enemy's information systems. The MLRS launched Army Tactical Missile System (ATACMS) Block I/IA munitions are optimized for attack of such high value/high pay-off targets as the enemy information system. With its precision attack, large area footprint and DPICM payload, ATACMS is ideally suited for the attack of these types of "soft sitters" at ranges out to 300 kilometers. ATACMS puts the enemy's entire tactical command, control, communications, computers, and intelligence (C41) network at risk. Figure 12 below illustrates the tremendous value added of specifically targeting and attacking the enemy's ability to gather and process information.

The artillery has established tactics, techniques and procedures (TTPs) that contribute to gaining information dominance. Two of the more relevant concepts being explored are the sensor to shooter and joint precision strike TTPs. These TTPs are designed to provide the capability to engage the enemy in the minimum time possible and take away his ability to operate inside the friendly commander's decision cycle.

These TTPs basically involve specific and unique control procedures and communications links for processing information, with the intent being the rapid dissemination of targeting data to an appropriate weapons system. By locating the JSTARS ground station module (GSM) with the MLRS battalion, mission processing times can be reduced by more than 75 percent.[14] These TTPs emphasize careful analysis of target attack timelines in relation to target dwell times, and specific weapons-target pairing to ensure all off the critical variable are addressed (includes target location error, posture of target, dwell time, attack system responsiveness, weapons circular error probable and probability of kill).

The Force XXI artillery is explicitly designed and organized to conduct combat operations in the Information Age. As a whole the future artillery has a much improved capability for information operations. The Force XXI FA is better able to gain, process, distribute, and use than any previous artillery force. It is also better able to attack the enemy's capability than ever before, with even greater potential for command and control warfare (C2W) in the near future.

Currently there are cannon projectiles in the global inventory that carry a variety of antiradar/antiradio submunitions specifically designed to attack the enemy's information systems. With relatively little effort, ATACMS missiles could be made to carry these existing submunitions, which are designed to jam the enemy's communications networks, or dispense chaff to confuse or jam enemy air defense radar. It seems very likely that ATACMS could carry antiradar/antiradio submunitions. The necessary sensor and lethal mechanism technologies exist today. With a relatively low-cost engineering, manufacturing, and development (EMD) effort the artillery could develop a significant hard-kill capability optimized against a wide variety of sensors and communications devices.

This analysis provides only a limited examination of the current and developing capabilities the field artillery will have for gaining information dominance. But it can be readily seen that the artillery will play a significant role in allowing Force XXI to become an information dominant force. The field artillery has the doctrine, the weapons, the fire control systems, and TTPs required to execute this doctrine already in place. It seems clear that the King of Battle will retain its ability to provide decisive support to commanders of the Information Age.

Shape the Battlespace

My analysis of the Force XXI FA force structure in relation to the operational pattern--shape the battlespace--examined the material systems, organizations and operational concepts to determine what capabilities the future artillery has to shape the battlespace. The ability to shape the battlespace is a prerequisite for successful execution of the other operational patterns. Shaping the battlespace is the critical capability that allows the commander to apply combat power at the decisive point without encumbrance.

The purpose of shaping the battlespace is to set the conditions for friendly success in decisive operations. The overall goal is to eliminate the enemy's capability to fight in a coherent manner before committing friendly forces to decisive operations. To accomplish this the commander first determines when, where, and what posture he wants the enemy forces in before the decisive action. Then he must define how and where friendly forces will be postured to apply combat power and take advantage of the operational environment. The operational environment covers the length, depth and height of the battlespace and includes the dimensions of space and time, as well as the electro-magnetic spectrum.

The commander then develops his scheme of fires, which identifies the critical fire support tasks. Critical fire tasks are those tasks which if not accomplished will cause the unit to fail, regardless of what other tasks the force accomplishes. Critical fire tasks articulate the attack guidance of the commander. They also include the purpose, method and endstate for each task.

Many of the commanders critical fire tasks require the use of the artillery's deep strike capabilities to shape the battlespace. The deep and simultaneous attack capabilities of the artillery are central to shaping the battlespace. The deep fires capability of the future artillery allows Force XXI to:

1. Adjust the presentation rate of enemy forces by delaying, disrupting or destroying armored combat vehicles before they can engage friendly troops.

2. Attack the enemy C4I network to disrupt and degrade the efficiency of his information operations. This includes blinding of RSTA assets.

3. Attack high-payoff targets that pose an imminent threat to Force XXI operations. These include such targets as ADA sites, helicopter staging areas, tactical ballistic missiles, and electronic warfare systems.

A deep attack capability allows an outnumbered force to achieve decisive victory with minimal casualties. The effectiveness of deep attacks was shown during Operation Desert Storm, and has been validated in numerous combat simulations. In Battle Command Training Program (BCTP) exercises the importance of the deep attack capability has been repeatedly observed. Combat Training Center Bulletin No. 94-1 it states, "if the deep attack is early and decisive, chances for the successful outcome of the battle are significantly improved."[15]

The ability of Force XXI to decisively engage enemy forces at extended ranges could possibly eliminate the need for the close fight. During PW/AWE 1994 the importance of deep attacks with FA delivered PGMs was convincingly demonstrated. Three excursions were run that illustrated the contribution that artillery delivered deep attacks can make to shaping the battle. In the base case, the Mobile Strike Groups engaged in the close battle were attrited to an average of 59 percent, and the entire MSF was attrited to the 65 percent level.[16] In Alternative 1, two MLRS battalions were replaced with two Crusader battalions, which resulted in a more intense close fight and the worst attrition rates of any alternative.[17] In Alternative 5 the number of ATACMS missiles was tripled, which resulted in the MSF avoiding the close battle and achieving its operational objectives with the least amount of attrition.[18] Figure 13 shows that when the MSF had more artillery assets to conduct deep attack the close battle was less intense and survivability was improved.

Fundamental to the ability to shape the battlespace is the ability to cover it with fires. The future FA force will have the ability to reach out to ranges in excess of 300 kilometers and strike with pinpoint accuracy. This capability to range the battlefield to this depth provides the ability to attack high value targets previously beyond reach. The future artillery brings to Force XXI the capability to maintain a continuous position of advantage relative to the enemy, the ability to maneuver by fire. Decisive effects can be achieved virtually anywhere at any time and with minimal risk. Artillery fires can range the entire battlespace largely unaffected by terrain, weather, and air defense threat. The Force XXI commander's ability to affect the battle will be limited only by the time of flight. Threat forces will have to account for the increased capability of Force XXI by taking active and

passive force protection measures to avoid being targeted. This will degrade the effectiveness of the functions and formations they seek to protect, or cause them to divert protective assets from somewhere else.

Crusader's maximum range requirements of 40 to 50 km gives Force XXI the ability to outrange most of the cannon systems currently available and under development. Figure 14 shows the range capabilities for the most common cannon systems found in the Southwest Asia and Northeast Asia theaters of operation.

For several decades U.S. artillery has been routinely outranged by threat forces. Many of the cannon systems found in global inventories outranged even the Army's principal long range shooter, the MLRS. The Crusader system and the MLRS Family of Munitions (MFOM) will remedy this critical deficiency. The simple tactical truth is that more range is better; outranging the enemy significantly reduces casualties and increases force exchange ratios. The Force XXI division commander will have access to number of systems that can effectively engage a variety of targets (hot/cold, moving/stationary, hard/soft) out to 300 kilometers.

Crusader will shoot further and with greater accuracy. Crusader will provide an absolute range increase of between 10 to 20 kilometers. This equates to a relative increase in range of up to 73 percent for unassisted rounds (23 km versus 40 km) and an increase of up to 66 percent for assisted projectiles (30km versus 50 km). This extended range capability is made more valuable by the enhanced accuracy of the Crusader. The accuracy of an artillery weapon is typically a function of its range. The longer the range the greater the dispersion of rounds (errors in precision and bias are magnified at greater ranges). Crusader has an accuracy requirement of 3 mils. This equates to a circular error probable (CEP) at 25 km of 80 meters. This is significantly better than the Paladin which had an accuracy of 6 mils (CEP at 25 km of 155 meters).

Crusader will be as accurate at 30 kilometers as is Paladin at 15 kilometers. This improvements should not be perceived as merely incremental change. This changes equate to a first round fire for effect capability at nearly twice the range as previously.

The improved range and accuracy of the Crusader allows the maneuver commander to engage more targets more effectively, and a different variety of targets than with the Paladin. As the maximum range capability increases so does the average gun-target range of missions fired, as shown in figure 15. In both the SWA and NEA scenarios, targets were consistently engaged beyond the maximum range of the Paladin. The greatest number of missions fired by the Crusader were in the 30 kilometer and greater category, which shows the value of extended range in the direct support role. During the SWA decisive operation scenario, 87 percent of the missions fired by Crusader at targets in excess of 30 kilometers were fired at command, control, and communications (C3) and logistics targets.[19] Before Crusader, these high value/high-payoff targets were out of reach of direct support units.

The rocket and missile delivery capability of the future FA will be significantly enhanced by the development and fielding of the expanded MLRS Family of Munitions (MFOM). The suite of ATACMS munitions and the MLRS Smart Tactical Rocket (MSTAR) will provide an unmatched ability to strike at tactical and operational depths with great precision. The extended range versions of the ATACMS missiles will reach out to a depth of 300 kilometers and deliver their submunitions over the target with less than 50 meters of error. The MSTAR and the extended range guided rocket will provide the ability to engage point and area targets with an accuracy of less than 3 mils out to ranges between 50 to 80 kilometers. Both of the launch platforms, MLRS and HIMARS, will be able to deliver the entire MFOM with the same degree of responsiveness and accuracy. No

other artillery force can equal the capability that the MFOM will provide.

Equally important to the ability to maneuver by fire is the ability to gain positional advantage through maneuver. During ODS the inability of the fire support system to keep up with maneuver units became woefully clear. Maneuver units were forced to limit their rates of advance to the speed of their artillery, or risk outrunning their fire support. The speed and tactical mobility of the self-propelled artillery had not been significantly improved in over thirty years.

The ability to maneuver artillery will be critical to Force XXI operations. Force XXI operations stress the use of maneuver tactics, to strike the enemy at times and places where he least expects and can effectively respond. The future artillery will possess tactical mobility the equal of the maneuver arms. The future artillery will be able to "run and gun" with the maneuver arms. The charts in Figure 16 below show the effects that improved tactical mobility has on the ability of the cannon force to keep up with maneuver units and maintain the ability to provide as much of their range capability forward of the front line of troops (FOFLOT).

The charts illustrate the effect that improved tactical mobility has on extending the "useful" range of the artillery. Useful range is defined as the range forward of the front line of troops. What these charts show is that as friendly forces move, Paladin is less able to keep up with the force, and its ability to range forward of friendly troops is reduced accordingly. In periods of rapid and sustained movement by friendly forces, Paladin was only able to provide supporting fires 5 to 15 kilometers forward of the front line of troops. The Crusader equipped force was able to keep up with the maneuver forces and could consistently provide supporting fires 30 to 40 kilometers FOFLOT. The bottom chart

shows that Crusader will be able to consistently provide at least two-thirds of its maximum range capability FOFLOT. No more will maneuver commanders be forced to choose between outrunning their fire support or slowing their attack.

This mobility will allow the artillery to perform tactical operations that before were impossible. The enhanced mobility and survivability of FA systems will allow positioning at the forward edge of the battle area (FEBA) and even well beyond. The future artillery can be positioned well forward to enable the attack of targets out to the maximum ranges of the systems. No longer will commanders be forced to choose between the ability to maximize range, or the survivability of their direct support artillery.

The artillery is developing innovative tactics, techniques and procedures to take maximum advantage of the improved mobility that the future force will have. One such operational concept is the strike force concept. Strike force operations are designed to take maximum advantage of the improved mobility, advanced sensors, dynamic obstacles, and brilliant munitions of Force XXI. The artillery could form the nucleus of special "hunter-killer" strike forces task organized to engage specific enemy forces or functions, not seize terrain. These forces will penetrate deep into the battlespace to launch attacks against enemy targets previously secure from attack. In offensive operations these strike forces could be used for deep, precision type raids of short duration. Missions will include attack of the following high payoff targets: enemy C4I nodes, air defense artillery sites, ballistic missile sites, and logistics facilities or transportation networks. In defensive or delay operations these strike forces could be employed in quick hitting ambushes, to cover ambushes by other strike forces, to cover obstacles, and/or to attack the enemy in his flank or rear.

The future artillery force will have a significantly improved ability to conduct artillery raids using air assault techniques. The use of the helicopter's vertical envelopment capability allows rapid movement of the artillery throughout the battlespace, enabling the concentration of combat power virtually anywhere. Air mobility allows the commander to rapidly position his artillery at depth at times and places the enemy cannot anticipate, react to or control.[20] The ATCAS system brings the future artillery an enhanced capability to conduct air mobile operations. The lighter weight of the ATCAS will allow increased operational flexibility in planning and executing air mobile raids. The lighter weight means the mission aircraft's operating spectrum is increased, in terms of the allowable conditions of altitude, temperature, weather. ATCAS can be flown in conditions that the M198 would not allow. Also, the lighter weight ATCAS allows more ammunition to brought on the mission than the heavier M198.

The future artillery force structure will provide a dramatically improved capability to shape the battlespace. Force XXI cannon and rocket systems will have an unprecedented ability to use fire and maneuver to span the depths of the battlefield. The artillery contribution to shaping the battlespace consists of far more than just the delivery of preparatory fires or deep battle, although the ability to strike deep is an essential to the capability to shape the battlespace. The future artillery, with its ability to effectively engage point and area targets in all tactical and environmental conditions, provides the ability to attack enemy functions and formations identified by the commander as critical to his concept of the operation. The fires of the future artillery force will provide the commander the ability to set the conditions for decisive engagements.

Conduct Decisive Operations

My analysis of the Force XXI FA force structure in relation to the operational pattern--conduct decisive operations--examined the issue from the levels of both individual systems and the aggregate force. The capabilities of the weapons systems that will make up the force and the future artillery forces organizations and operational concepts were examined to see how well they will support decisive combat operations. Fires in support of decisive operations generally fall into one of the following categories: close support fires, suppression of enemy air defense (SEAD), fires to support information operations, counterfires and strike fires.

The results are clear. The Force XXI artillery will be capable of providing a significantly greater volume of increasingly lethal fires, at greater ranges, and at a higher tempo. This capability is the result of many factors that all converge to make the Force XXI artillery a more decisive force on the battlefield. There are more artillery battalions available to support the maneuver units (nearly a one to one ratio). There are nearly 60 percent more firing units on the battlefield (72 firing platoons vs. 45). There are 35 percent more weapons platforms available (216 vs. 159) to support combat operations. The future weapons systems can range farther, are more responsive, accurate and mobile than the systems they will replace. This increased number, density and range capability of firing units will significantly increase the area of operations that can be covered with immediately responsive fires. These capabilities enable the creation of spheres of fire that will allow Force XXI to attack a wide spectrum of targets simultaneously, denying the enemy any options, robbing him of the ability to conduct decisive operations.[21]

Future artillery delivered munitions will be more precise and lethal. The artillery systems in the Mobile Strike Force are projected to be able to deliver over 7,000 precision projectiles in a ten minute time span.[22] The artillery is developing the tactical and operational procedures that maximize the capabilities inherent in the force structure. ST 71-100-2010 describes the necessary procedures to direct and coordinate the brief, violent attack--the ambush dynamic--against enemy formations up to corps size. As a whole, the future artillery force structure provides a dramatically improved capability to conduct decisive combat operations. All of these capabilities will allow the future artillery to retain the title of biggest killer on the battlefield.

The future artillery is capable of providing highly responsive and lethal close support fires. The purpose of these fires is to support the maneuver and protection of ground forces in contact from attack by mounted and dismounted enemy forces. During PW/MSF AWE 1994, the MSF artillery was responsible for killing more than 400 enemy combat systems out of 700 OPFOR close battle kills.[23] Shown in figure 17 are the OPFOR combat losses caused by friendly combat systems.

Decisive operations in the close battle requires the complementary fire support capabilities provided by a mix of cannon and rocket systems. An early effort at artillery force design for the MSF examined the potential of replacing the cannon systems with MLRS in the direct support role. By itself, MLRS is not able to provide effective fires to the close fight. Cannon systems remains the direct support weapon of choice for decisive operations. Cannons are more effective than MLRS at close ranges, and against hard or point targets. MLRS is more effective at greater ranges, against large area targets, and the ability to quickly surge or mass firepower. Figure 18 shows the

effectiveness of the mix of rocket and cannon systems in the close support mission, with cannons providing direct support and reinforced with rocket fires. Decisive operations in the close battle area needs the complementary capabilities provided by a cannon and rocket weapon systems. When combined in the appropriate ratio, the two systems provide decisive fire support to the close battle.

The improved mobility of the Crusader will enable the future heavy cannon artillery to provide better direct support to maneuver units. Crusader units will be able to conduct tactical and survivability moves faster. This means the artillery will be in position ready to fire more often. This enhances the ability of the artillery to provide immediately responsive fires. Figure 19 shows the effect that improved tactical mobility has on the ability to provide close support fires. The chart on the left shows that Paladin spends approximately 25 percent of the available time conducting tactical and survivability moves. The chart on the right shows that Crusader spends less time moving, approximately 15 percent is spends more time in position ready to fire. The bottom chart shows that Crusader is better able to support high tempo operations. Crusader allows units to move faster, more often, and still conduct more fire missions in support of the close battle.

Another critical measure of decisive combat is the lethality of the force. Crusader provides a significant increase in lethality. Lethality is determined by a number of factors, including time in position and rate of fire. Crusader can fire more missions than Paladin, because it is in position and available to fire more often. Crusader also has a much higher rate of fire, a rate of ten to twelve rounds per minute.[24] Crusader will spend less time on any given mission. Crusader's higher rate of fire will allow more targets to be attacked, more quickly. The combination of these two factors allows Crusader to fire more

missions in a given period of time. The difference between the Crusader and Paladin is most pronounced in the SWA scenario, where targets are more fleeting due to the rapid movement of the Blue Forces. In the SWA scenario the enhanced responsiveness of the Crusader enabled 44 percent more missions to be fired than the Paladin force. The increased responsiveness and lethality of the Crusader system is not as clearly illustrated in the NEA scenario, because targets continue to close and present themselves, the proverbial "target-rich environment." Figure 20 below illustrates Crusader's increased responsiveness and lethality.

Crusader's unique ability to conduct multiple round simultaneous impact (MRSI) missions is a truly significant force multiplier. Crusader will be able to deliver four to eight rounds, depending on the range to the target, that impact at the same time and place. In essence a single Crusader can bring to the force the same combat capability as a battery of conventional howitzers. However, it must be noted that an MRSI mission increases the susceptibility of the howitzer to location by counter battery radar. The MRSI capability must be paired with a shoot and scoot capability and improved tactical mobility in order to maintain survivability.

The Crusader-equipped force is better able to conduct decisive combat operations. The Crusader provides Force XXI immediately available fires of increased accuracy and responsiveness. The Cost and Operational Effectiveness Analysis (COEA) results show that Crusader increases total force effectiveness by 13 to 62 percent across a wide variety of potential combat scenarios.[25] Crusader's greater range and increased rate of fire allows Force XXI units to fight with fires in depth, striking enemy forces with unparalleled lethality. By killing the enemy deeper and earlier, Crusader reduces the number of direct fire engagements by up to 40 percent, and provides friendly forces increased freedom of maneuver

in the close fight, resulting in a more lethal and survivable force.[26] Such a force kills up to 75 percent more enemy systems than a Paladin-equipped force, while suffering up to 40 percent fewer losses.[27] Figure 21 shows the overall contribution to force effectiveness made by the Crusader.

The ability to negate the enemy's artillery is a crucial aspect of decisive operations. The future artillery must provide an effective counterfire capability because the OPFOR artillery consistently represents the greatest threat to MSF operations. Combat simulations show that the OPFOR artillery consistently represents the greatest threat to friendly forces. The Army's first precision guided munition, SADARM provides the capability to decide the counterfire battle (See Figure 22). SADARM is four to seven times more lethal than DPICM in the counterfire role; and seven to twenty-one times more lethal than DPICM in the close support and interdiction roles.[28] SADARM makes the force more effective in a variety of combat scenarios. Shown in Figure 22 below is the contribution that SADARM makes to force exchange ratios. These are the figures for the base version of SADARM currently in limited rate production. The SADARM pre-planned product improvement (P3I) variant will feature a larger search area (3X) and an improved lethal mechanism, thereby increasing effectiveness against moving targets. Crusader paired with SADARM and the FireFinder radar will make a truly lethal counterfire team.

As a whole the future artillery force structure will provide a dramatically improved capability to conduct decisive combat operations. The improved capabilities of its weapons systems, the increased lethality of its munitions, and the effectiveness of its organizational and operational concepts all contribute to making the future artillery more capable of decisive operations. The conduct of decisive operations is

the most critical of the Force XXI patterns of operations. The future artillery will not be found lacking in this area.

Sustain and Transition

My analysis of the Force XXI FA force structure in relation to the operational pattern--sustain and transition--examined the issue from both the systems level and aggregate force levels. Individual systems that will comprise the force and the total MSF artillery force structure were examined to see how well the future force structure enables sustainment and transition operations. The results are something of mixed bag. Some systems and capabilities will offer significant improvements, while other aspects provide no better capability than current systems. As a whole the future artillery force structure will be better able to sustain and transition than the current force structure.

The most significant improvement that the future artillery will have in the area of sustainment is the ability to quickly resupply howitzers with fuel and ammunition. The Future Artillery Resupply Vehicle (FARV) is an extremely important factor in the combat effectiveness of the Crusader. The FARV will replace the Field Artillery Ammunition Supply Vehicle (FAASV). The FARV will provide the Crusader with ammunition and fuel. The FARV will be able to perform a completely automated rearm/refuel of the Crusader in 12 minutes. The FARV will have an increased ammunition storage capability, between 130-200 rounds. The FARV will have a capability to store more than 350 gallons of fuel.

The FARV will have many of the same design characteristics that the Crusader has, making it significantly more capable resupply vehicle than the FAASV. The FARV will have mobility and survivability design features equal to the Crusader. The increased mobility and survivability of FARV is a significant contributor to the combat effectiveness of the

Crusader. Computer simulations showed that Crusader is not nearly as effective a system without the sustainment capabilities provided by the FARV.

During periods of peak demand in mid and high intensity conflict, a single Crusader will be able to deliver 35 tons of 155mm munitions in a 24 hour period. A single Crusader battalion will require over 600 tons of ammunition a day--a daunting if not impossible logistics challenge. The FARV will provide the ability to get the ammunition from the battalion combat trains area, but the battalion must first be able to haul this quantity from the brigade ammunition transfer point. The battalion ammunition section will be equipped with the Maneuver Oriented Ammunition Distribution System Palletized Loading System (MOADS-PLS). MOADS-PLS was specifically designed to meet the high volume high tonnage Class V requirements of the artillery. The MOADS-PLS system is designed to provide up to 3,500 tons of ammunition a day to the a heavy division. The future artillery will continue to demand the lion's share of this class of supply.

Typically artillery ammunition accounts for almost 75 percent of the total bulk cargo moved by the supply system. This is an extraordinary logistical feat requiring a significant amount of resources (personnel, transportation, and material handling equipment). One of the significant advantages offered by the enhanced lethality of PGMs is their payoff in terms of reduced logistics requirements. Smart munitions like SADARM are much more efficient killers, which means that fewer bullets are needed to achieve the desired effects. SADARM can provide efficiencies along the order of a ten-to-one reduction in the number of rounds required to achieve the desired effects. PGMs are not the only munitions with improved lethality that will provide reduced logistics burden. GPS fused projectiles also promises to significantly reduce the

number of "dumb" bullets required to achieve desired effects. The rounds should provide an increased efficiency on the order of at least a three to one reduction. The development of guided rockets will also significantly reduce the Class V logistics burden. However, the "kill transfer" phenomenon may offset some of this efficiency/advantage, because the artillery can kill more efficiently and effectively it will engage more targets than before.

The future artillery will have to meet greatly increased Class II requirements. It is too soon to know exactly what kind of fuel requirements a Crusader battalion will have. However, it seems certain that Class III requirements will increase significantly. The Paladin weighs 33 tons and is powered by a 440-horsepower engine. It seems reasonable to expect much greater fuel consumption rates from a 55-ton vehicle with a 1500-horsepower engine. The FARV will also require significantly more fuel that its predecessor. The future artillery battalions will require amounts of fuel more nearly equal to an M1 tank battalion than the Paladin battalions of today.

All the future artillery systems require improved reliability, availability and maintainability (RAM). It is again too early to say with any certainty whether the new systems will actually be more reliable than the ones they replace. Computer simulations shows that the Crusader will be able to sustain combat operations longer than Paladin, because of better RAM. The IFCS/ILMS upgrades for the M270A1 launcher were developed specifically to improve the RAM and reduce operating and sustainment costs. A fleet of new artillery vehicles is almost certain to have better reliability than the current force, which has vehicles approaching three decades of service.

The increase in allocation of FA brigades to support a division will create a significant resupply burden for the corps support

battalions located in the division rear. This mean that there will be a total of six artillery battalions that will require logistics support from EAD CSS units. It has been suggested that the Army design a CSS unit specifically for providing support to these two FA brigades. The Army Science Board specifically recommended the creation of such units in the reserve components to support the increased number of RC FA brigades.[29]

The reorganization of the heavy cannon battalions under the three by six configuration is likely to decrease the amount of logistics support required. For the simple reason that there are fewer system and personnel that will require support. The Table of Organization and Equipment (TOE) structure for the reconfigured 3x6 battalions has not been established, so it is too soon to tell if the organic support capabilities will be reduced. Given the need to sustain high tempo operations and the increased requirements for fuel, ammunition and RAM, the future heavy cannon battalions should retain of the organic CSS assets they had under the 3x8 configuration.

The future artillery will benefit from many of the logistics initiatives that are being implemented across the force. Such concepts as anticipatory logistics, total asset visibility, and split based support will contribute to the ability of the future artillery to sustain itself and transition to future operations. It is not in the scope of this thesis to do a detailed analysis of the logistics capabilities and requirements of the future artillery force. However, based on an examination of the systems and organizations of the future artillery force it seems likely that it will be better able to sustain combat operations and transition to future operations.

Suitability Across the Spectrum of Conflict

> The nation cannot afford to maintain an army of armies in the early twenty-first century. The requirement to be trained and ready to win the land battle remain-the absolute priority. Well-trained and disciplined units, provided with sufficient time and resources to train, can transition to OOTW missions as required.[30]
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> TRADOC PAM 525-5

The future artillery must be able to respond effectively to the challenges of operations across the entire spectrum of conflict. The preceding analysis has shown that the Force XXI artillery force structure is optimized for medium and high intensity combat against a peer force. The ability of the future artillery to provide fires to protect the force, shape the battlespace and conduct decisive operations is clear. There can be little doubt that the future artillery will be without equal in its ability to find, attack, and destroy conventional and high technologically armored and mechanized forces.

It is not clear that this same force will be as effective against an asymmetric threat. A threat that does not fight the way we expect to fight, that does not present the types of targets our weapons and munitions are designed to attack, that does not present the needed signatures to our sensors might reveal an artillery incapable of effective response--a digital dinosaur. An artillery force and its associated organizational and operations concepts designed for high tempo combat operations against a dynamic, technology-based threat is possibly less effective at the alternative end of the threat spectrum. Against an unconventional threat, the utility of the future artillery force could be limited. This portion of the thesis will address the usefulness of the future force structure in low intensity conflict and MOOTW.

Recent deployments by 25th and 10th Infantry Divisions without their artillery, and the minor role played by the artillery packages inserted into Joint Readiness Training Center (JRTC) scenarios seems to indicate a negative trend regarding the use of artillery in the LIC/MOOTW environments. Artillery periodicals and other military publications have not provided much of a vision regarding the innovative and effective uses of artillery in LIC/MOOTW environments.

Typical articles addressing the use of the artillery in LIC instruct the reader on how to prepare and harden the static positions. Articles on the uses of artillery in MOOTW are virtually non-existent. This reflects the general institutional difficulty in expressing the effective uses of firepower in LIC and MOOTW. To many, the utility of the field artillery, typically seen as an imprecise, area weapon is extremely limited in these environments. The issues surrounding the effective use of field artillery in LIC/MOOTW are much more complex and involved than how to build a fire base.

Before proceeding any further, I should separate and draw some distinctions between LIC/MOOTW and conventional "war." For the purpose of this thesis, LIC is distinguished from a medium and high intensity conflict mostly by the nature of threat and the tempo of combat operations. Operation Desert Storm is an example of medium and/or high intensity conflict. The Vietnam War and Operations Just Cause and Urgent Fury are examples of what I call "low intensity conflict," realizing of course that no conflict is low intensity when someone is shooting at you. MOOTW includes all military operations short of war. On many occasions the line separating LIC and MMOTW will blur. The general distinction is that in medium and high intensity conflict the threat possesses the ability to conduct joint and combined arms operations, in LIC the threat is mostly small arms and a limited indirect fire capability, and in MOOTW

the physical threat is usually limited to sniper and mines. Both environments will be characterized by the presence of civilians. In these environments there is much more involvement with the civilian population, both hostile and non-hostile. The need to be able to discriminate between friendlies and non-friendlies takes on ever-increasing importance, particularly for the artillery.

Most security analysts and writers agree that the majority of conflicts in the future will be low intensity struggles, reflecting some group's dissatisfaction with the current state of affairs. These conflicts are typically rooted in long standing ethnic, racial, political or socioeconomic divisions. These conflicts often become protracted and violent due to the insoluble natures of the problem. The U.S. could easily become embroiled in a low-intensity conflict that grows out of an involvement that was first purely humanitarian. It is not too difficult to imagine a course of events that would see the current U.S. peacekeeping mission in Bosnia-Herzegovina develop into a long and bitter episode of low-intensity conflict.

The sociopolitical nature of these types of conflicts, the comparatively limited military capabilities of the threat, and the scope of the civilian presence place different demands and priorities on the field artillery. It seems evident that success in LIC depends less on the sheer quantity of destructive firepower, and more on the timely, measured use of appropriate force.[31] It has been observed that in LIC, perhaps even more than other conflicts, the effectiveness of artillery fires depends on the speed and accuracy of delivery.[32] These comments lay bare two of the most common and significant arguments against the use of the artillery in low-intensity conflicts.

One of the criticisms leveled against the effectiveness of the field artillery in LIC is that it is too slow, lacking the speed to

adequately respond to fleeting targets. The mobility of low intensity threats usually prevents a ponderous and sluggish fire support system from responding effectively. A common theme in all the limited wars fought by the major powers since World War II has been the inability of the firepower dominant force to find the enemy with sufficient timeliness to fully and efficiently exploit the firepower advantage.[33]

The future artillery will be no muscle bound giant, incapable of quick or flexible response. The future systems and operational methods will enable much greater responsiveness. Increased automation and improved C4I networks, and procedures will reduce the time between target acquisition and steel on target. The current digitization efforts will provide a significant increase in the responsiveness of the future artillery. Calls for fire will flash from the sensor, man or machine, and be speedily routed to the most appropriate delivery units. The digital networks will enable nearly instant determination of whether the fires require clearance, if they violate fire support coordination measures or rules of engagement, or pose any risk of fratricide. The development of on board fire control systems, automated rammers, and automated gun laying and positioning systems all serve to enhance the responsiveness of the future artillery.

The use of appropriate tactics and decentralized C2 will enhance responsiveness. The use of direct, digital sensor-to-shooter links will tremendously speed the process of the delivery of fires. In LIC/MOOTW the need to mass fires is not often a critical concern. This will allow the increased use of dedicated batteries, linking maneuver units directly to firing batteries for rapid response. The improved performance capabilities of the future cannon systems will increase the effectiveness of smaller firing units. The burst fire capabilities of ATCAS or

Crusader will allow one battery to provide the effects of a larger firing unit.

Criticism regarding the accuracy of the artillery reflects past problems of inadequate target acquisition and delivery errors. In LIC, the artillery's greatest need is for a more accurate and discriminating target acquisition capability. The single greatest failure of the firepower system in Vietnam was the inability to develop reliable, targetable intelligence.[34] In LIC this challenge is made particularly difficult by the comparative absence of the large machines and communications-electronics devices that our current generation of target acquisition devices are capable of finding. In LIC and MOOTW what is needed are systems capable of accurately locating more subtle signatures, such as an individual's body heat or the trajectory of a single sniper round fired at a U.S. peacekeeper. Research teams have developed a sniper location system that can accurately track bullets in flight back to their origin within hundredths of a second.[35] The potential of such a system as a "mini-Firefinder" is great. Immediately suppressive fires could be directed on snipers, thus discouraging their practice.

Inaccurate targeting has traditionally been the largest source of artillery error.[36] All of the range, precision, and lethality that the artillery can bring to the battlefield is of little value if the initial target location is inaccurate. Accurate target location is particularly challenging in the restricted terrain favored by insurgents and guerrillas. GPS has dramatically improved the ability of the forward observer to accurately determine target locations. With the fielding of GPS and laser designators, the single greatest source of artillery error has been almost entirely eliminated.

The use of artillery in combat operations in LIC and MOOTW is often subject to extremely restrictive rules of engagement (ROE). This

will require the artillery to increase the accuracy of its fires. To increase its utility in restrictive ROE environments, the artillery must develop the sniper capability of the marksman. Pinpoint accuracy is now routinely expected, and the future artillery can deliver. Recent improvements to the weapons systems and munitions will enable a degree of precision never before seen. Automatic gun-laying systems will increase the accuracy of the gun's orientation for range and azimuth, and reduce the possibility of error on the gun. It is expected that such improvements to the guns will enable delivery of 75 percent of "dumb" ballistic rounds within a radius of 200 meters at a range of 40 kilometers.[37]

The development of GPS fuzes will also contribute to increased precision. There are a number of GPS applications currently being studied. GPS fuses will allow delivery units to conduct precision registrations with a single round. The use of registration allows correction for the effects of all nonstandard firing conditions. In LIC, registration is an appropriate technique for improving the accuracy of fires, because of the reduced threat of counterbattery fires. Combining a GPS fuse with a simple trajectory correction method would give the artillery the ability to routinely achieve fire for effect accuracy with the first round.

HE rounds with GPS fuses may be ideal smart munition for low intensity conflict. Typical smart munitions and PGMs require a distinct acoustic, millimeter wave or infrared signature for the sensors to detect. In LIC these types of signatures are not likely to be common, in which case these "smart" rounds are not so effective. The ability to achieve precision effects with a "dumb" round will bring an unprecedented capability to the battlefields of limited war.

The artillery would be well advised to develop specific munitions and fuses for use in the LIC and MOOTW environments. An area that is getting an increasing amount of study is the concept of artillery delivered non-lethal munitions. The artillery should also develop fuses and munitions suitable for use in the environments where LIC threats enjoy their greatest advantage. The effectiveness of the standard fuses and projectiles is degraded in jungle environs with thick overhead growth.

The material systems and munitions of the future artillery will increase the effectiveness of the artillery in LIC. The future systems will be more responsive and more accurate. Their increased responsiveness and precision will make the future artillery a more flexible and suitable system for use in low intensity conflict. Given an accurately located target, the artillery will be able to respond with extraordinary accuracy, providing increased effectiveness, significantly reduced collateral damage and lower risk of fratricide. The artillery will have the ability to put rounds exactly where the observer wants them.

The greatest challenge lies in the proper application of this improved tool of war. There is the risk that the improved capabilities of the artillery will result in a return to the patterns of use demonstrated in the Vietnam War, where fire was used indiscriminately and often to little effect. It was reported that only 15 percent of the artillery was delivered in support of friendly ground action.[38] The practice of firing harassing and interdiction fires at trail junctions or likely spots on the map was both unsuccessful and inefficient. Some units reported an average expenditure of 1000 rounds or more per kill. Other times, when an appropriate target was found, an insufficient quantity of fires would be delivered. For artillery to be effective it

must be used in a manner consistent with its capabilities and limitations.

The cannon is not a particularly useful tool for military operations other than war. Artillery is a weapon of war, designed to kill people and destroy equipment on a large scale. It is an area weapon, although one capable of considerable precision. Whenever there is the possibility of actual hostilities, no matter what level intensity, the artillery and its capabilities will be needed. However, when the focus of an operation is not combat operations, the utility of killing machines declines. This problem is shared by other major weapons systems: tanks, infantry fighting vehicles, and attack helicopters.

The artillery does bring some significant capabilities to the MOOTW environment. The artillery force has a robust C2 structure, a strong support structure, and a large pool of manpower. An artillery unit can provide a significant number of flexible, highly skilled personnel that are capable of detailed planning and can execute tough, demanding tasks to standard, no matter what the mission. An artillery unit brings a disproportionately high number of radios and vehicles, which are particularly useful in MOOTW. LIC/MOOTW are manpower intensive activities and artillery units are relatively large units. However, the reduced crew sizes of the future systems will have a negative effect on the ability of the future force to conduct continuous operations, no matter what the mission. Fewer soldiers will be available to perform the tasks the unit has been assigned.

The studies and analyses done to support the development and acquisition of the Force XXI FA initiatives addressed a wide variety of combat scenarios. These future artillery system and organizations were subjected to a rigorous analysis of their cost and operational effectiveness in NEA, SWA, and European environment, in offensive and

defensive operations against a variety of threat forces. I found no evidence of a deliberate analysis of the effectiveness of the future artillery force in a LIC or MOOTW scenario. Either by design or default, the Force XXI artillery has been optimized for combat in mid and high intensity conflict. The apparent underlying assumption is that a force optimized for the high end of the threat spectrum can be made to work in the LIC/MOOTW environments.

This approach to force structure design is driven by economic reality. The nation simply cannot afford the luxury of training and equipping an "army of armies" with each force optimized for operations in the specialized conditions corresponding to their assigned niche. The first priority must be to national security. For the next one-half century or so this will continue to require a standing army with the capability to defeat threat forces equipped with significant numbers of tanks, infantry fighting vehicles, and artillery. The force must be able to do double duty: it must be able to win the nation's war, both large and small, and it must be able to secure the nation's peace. The future artillery is flexible and versatile enough to provide good service in both these situations. However, U.S. policymakers would do well to remember to never contemplate involvement in a limited war without a clear understanding of what firepower and technology can and cannot do.[39]

FM 100-5 defines versatility as "the capacity to be multi-functional, to operate across the full range of military operations and to perform at the tactical, operational and strategic levels." Versatility mandates a multifunctional capability. Our shrinking force structure does not have room for specialized, limited use weapons. The future FA is an extraordinarily versatile system. It will function in all tactical environments, providing flexible and immediately responsive

fire support day and night, in all weather conditions, and across the entire spectrum of conflict.

Appropriate Technology

The artillery is pursuing an aggressive force modernization strategy that seeks to leverage the capabilities of emerging technologies. Is the artillery pursuing a technology strategy that maximizes our strengths, one that is fully synchronized with current technological trends and with the efforts of the other battlefield operating systems? Now more than ever the artillery must invest in areas that will continue to offer growth potential in terms of new capabilities and avoid technological obsolescence. The artillery must take care to avoid pursuit of technologies and capabilities that will soon reach a dead end. This portion of the thesis will examine how effectively the artillery is pursuing technologies that will improve its capability to put steel on target.

The Crusader system is far and away the most technologically significant and risky venture the artillery is pursuing. Of particular concern is the maturity of the regenerative liquid propellant gun (RLPG) technology. RLPG technology promises great advantages in terms of cannon performance, enabling significant increases in range and rates of fire, while considerably reducing logistics requirements. RLPG represents the most likely area for breakthrough in cannon propellant technology. However, RLPG also is a high risk technology. There has been recent concern at the highest levels about the maturity of the RLPG technology.[40] If the artillery bets its future modernization on the Crusader, it is possible that the cannon system of Force XXI will be the Paladin, a direct descendent of the venerable M109 howitzer conceived of and brought on duty nearly one-half a century ago.

If other technical problems surface in the Crusader program it is likely there will be an increased number of voices calling for the program to be terminated, or continue development with the modular artillery charge (MAC) gun and the M1 chassis. This strategy would meet almost all of the operational requirements of the current Crusader at less cost and risk. However attractive such a strategy appears, the artillery must push forward with the liquid gun. Solid propellant gun technology is reaching the limits of its capabilities. Only new propellant technologies can offer the break through capabilities required to sustain our military capabilities in the twenty-first century.

This is not to understate the degree of risk that the RLPG technology poses to the success of the Crusader program. The Army should seek to collaborate with the Navy on continued development of the RLPG technology as a means of cost sharing. The Navy is currently exploring the development of a new 155mm gun system to replace the five inch guns on its surface warships. The advantages of RLPG would be of great value to the Navy. The Navy is also interested in developing a sea-launched version of the ATACMS. It seems certain some sort of joint research, development, test, and evaluation (RDTE) program could be worked out to each services benefit.

Cannon artillery systems have an indirect and direct fire capability. For too long the direct fire potential of the artillery has been ignored. The development of the necessary fire control systems and smart rounds for direct fire engagements (like the 120mm STAFF round) would give the artillery a credible direct fire capability. The German PzH2000 self-propelled howitzer currently under development is claimed to have a direct fire, first-round probability of hit from a static position as good as the Leopard tank.[41] The artillery should not necessarily try to match the capability of a main battle tank, but the demands of a

limited force structure require increased versatility and a multi-functional capability. Improving the howitzer's direct fire capability would provide a significant combat multiplier to a power projection army. The presence of a single weapons platform that could effectively engage enemy forces at extended and close ranges would enhance the combat power of early entry forces.

The artillery is on target in the area of ammunition development. It has identified critical capabilities and is exploring new technologies to meet these needs. Specifically, the Army has committed to the concept of smart and brilliant munitions. It has also identified the need for development of low cost "competent" munitions. GPS fuses are an excellent example of this type of approach. This will allow the application of new technology to existing material, providing improved performance at lower cost. GPS has resurrected the high explosive round. GPS fuzes that can identify their exact point of impact allow for quick registration of firing units. This capability will significantly increase the lethality of the artillery's most plentiful, inexpensive and ordinary munition. This will also significantly reduce the logistical challenges of Class V resupply and help to reduce number of submunitions left on the battlefield.

There is reason to believe that the terminal effects of the standard high explosive (HE) round have been significantly understated. The Study of Artillery Effects (SAE) test program recently found that HE ammunition was actually much more effective against dismounted infantry positions, obstacles and armored vehicles than had been previously thought. U.S. calculations of the number of rounds required to achieve a given expected fractional damage were much higher than estimates by the FSU. The actual terminal effects were very similar to the damage levels that Soviet effectiveness estimates predicted. To achieve 25 percent to

30 percent damage levels the Soviets said it would take approximately three times fewer rounds than U.S. estimates.[42] When combined with the increased accuracy offered by GPS fuses, the standard high-explosive round could become the munition of choice for many applications.

Another example of an innovative, yet relatively low technology solution is trajectory correction. Artillery weapons have greater dispersion in range than they do in azimuth. By aiming past the target it is possible to steer the round and achieve remarkable accuracy. Using GPS signals to determine its location while in flight, the fuse calculates and applies course corrections. The on board processor converts the GPS signals into course corrections by means of simple drag-inducing devices. Small changes in range are sufficient to provide the desired accuracy improvement. The projected error of such rounds at 30 kilometers is 100 meters in range and 15 to 50 meters in azimuth.[43]

The artillery is also pursuing a low-cost guidance system for its basic and extended range rockets. This technology will allow the precise attack of area targets. On a good day, the current free-flight basic and extended range rockets can achieve an accuracy of 10 to 15 mils.[44] This equates to an error of more than one-half a kilometer at a range of 50 kilometers. It is estimated that a simple and cost effective guidance system would provide rocket accuracy of 2 to 3 mils, an error of little more than 100 meters at 50 kilometers. This would increase the effectiveness of the MLRS system considerably, diminishing the number of rockets required to achieve the desired effects by up to 70 percent.[45]

We must accelerate the development of artillery delivered nonlethal weapons. As the frequency of operations short of war increases, the utility of nonlethal solutions to tactical problems increases too. These technologies may become tomorrow's weapons of choice. There are a number of nonlethal technologies that are being

considered that have artillery delivered applications. Artillery munitions could be used to deliver aerosol sprays containing metal weakening solvents, super caustics, super adhesives, antitraction solutions or other liquid agents. It seems likely that "flash-bang" or stun rounds could be developed for crowd control purposes. There is also potential for the delivery of "calmative" agents and a number of other nonlethal chemical agents.

The future artillery has extremely exciting possibilities for developing a real time target acquisition and battle damage capability with artillery delivered video imaging projectiles. All of the necessary elements of such reconnaissance systems are already at hand. Imagery systems that can survive the harsh environment of a cannon delivery system have already been demonstrated. It is believed that the technology is available to improve the present resolution of one x two meters down to at least 0.25 meters.[46] It is estimated that these projectiles could produced at a cost only 50 percent more than a standard high explosive projectile.[47] It should be a relatively easy feat to engineer such technologies for the less demanding stresses and challenges of a missile delivery system. Another technique being pursued involves the delivery of special video capable submunitions, dispensed over the area of interest at an altitude of about 1,000 meters, which then deploy small high glide aspect paragliders carrying low cost cameras and infrared sensors.

Successful development and application of fiber-optic technologies could complete the evolution of the artillery system. In the years preceding World War I, before the widespread use of indirect fire techniques, gunners visually acquired their targets, performed the necessary fire control on the gun, fired the round, and the observed the results. Since then, the practice of indirect fire has required the

artillery to coordinate three distinct functions: target acquisition, command and control, and finally the attack of the target. Technology is facilitating the return of these functions to the weapon. Already the fire control systems have left the Fire Direction Centers. Today's guns have on board fire control systems and communication devices, enabling sensors to talk directly to shooters. The Army is currently developing the ability to acquire targets using artillery launched projectiles, which can also assess the results of the strike. In the not too distant future the artillery will once again be directly linked to the battlefield, even at the greatest ranges.

Fiber optic technology will give the artillery a "man in the loop" capability. Gunners will be able to observe the battlefield through the eyes of their ordnance, searching for appropriate targets. The applications of such a capability would be revolutionary. Lethality would increase while virtually eliminating fratricide and collateral damage. Instead of a "fire and forget" capability the future artillery will have a "launch and look" capability. Technology is eroding the major distinctions between the capabilities of the indirect fire and direct fire platforms, while still preserving the benefits of a non-line of sight attack at depth.

We should not lose sight of low tech solutions to emerging operational requirements. The ability to acquire targets is going to emerge as the future bottleneck on the artillery's ability to provide fires.[48] Sensor technologies are not developing as fast as are the capabilities of the C4 networks. Current sensors have very specific performance capabilities and limitations. JSTARS is not particularly effective at locating and tracking moving targets in verdant or mountainous terrain.

Consider the individual soldier as a sensor. "The best broad-bandwidth sensor on the battlefield may be the soldier, not a coupled electronic device."[49] The augmented soldier with smart filter capability and extended loiter capability could be most effective sensor on the battlefield. The advantages that the soldier as a sensor platform provides are many. Soldiers are extraordinarily flexible, they can function in almost all tactical and environmental conditions. The soldier as sensor would be applicable across the spectrum of conflict, able to match the mobility of the low intensity threat and capable of hiding on the high intensity battlefield. Most importantly the soldier as sensor puts a "man in the loop" at the most critical point in the target attack cycle.

The soldier as sensor is not a new idea, what is different is the focus on the soldier as a solution to a technological and operational challenge. The effectiveness of the soldier as sensor has been extensively proven in combat. The artillery needs to sign up for this concept. The artillery has a need for more organic target acquisition assets. These sensor soldiers should be a 13 series military occupational specialty (MOS). The artillery community is making some preliminary rumbles regarding the use of teams of specially trained and equipped soldiers that would function as "super FISTs." These "striker" teams would differ from traditional forward observers (FO) or Fire Support Teams (FIST) in that they would not be assigned to a maneuver unit. Instead they would be employed more like scouts or Long Range Reconnaissance Patrols, or even a Forward Air Controllers (FAC). Their mission would be to locate and vector fires against critical targets the commander has specified for destruction. Striker teams would penetrate deep into the enemy zone to identify the location and coordinate the

attack of high payoff targets. These teams would rely on stealth, secrecy and the long range fires of the artillery to provide security.

The concept of the soldier as sensor puts emphasis on the areas where the U.S. is likely to maintain qualitative superiority over most enemies. The areas of people, mobile communications, and deep/precision strike are areas of U.S. relative advantage.[50] This concept supports and leverages the ongoing twenty-first Century Land Warrior (21CLW) initiatives at the Dismounted Battle Space Battle Lab at Fort Benning, Georgia.

Situational awareness offers the artillery tremendous potential. The areas of computers and communications are forecasted for the most significant and continued growth in the next several decades. The current efforts to digitize the force and provide common relevant picture could revolutionize the way artillery is employed. The amount of time spent processing a fire mission will be dramatically reduced. Fire support will become more flexible and responsive. Fires will be cleared as soon as the request for fires is initiated. Fratricide will be almost entirely eliminated. Increased use of pure sensor to shooter links will speed the delivery of fires as C4 capabilities are pushed down to the lowest levels on the battlefield. However, some caution is appropriate. We cannot fall victim to digital rapture. The full potential of situational awareness is dependent on ever lengthening and complex communications links. The susceptibility of this extended communications network to jamming or disruption is obvious. Information operations is a double-edged sword that must be carefully wielded. It can bestow many significant advantages, but it also creates many opportunities for exploitation. It should also be noted that many of the key components of the Army's digitization strategy are not contained in the POM.[51]

All in all, the artillery has established a sound strategy for the identification, development, integration and application of key technologies. Fort Sill is examining emerging technologies for solutions to the operational issues of the twenty-first century. The artillery is focused on identifying technological solutions that will help the future artillery put more steel on target, more quickly and more accurately. Examination of the fire support modernization plan in the Army Science and Master Technology Plan shows a forward looking organization, that is fully synchronized in its efforts. There is little danger that the future artillery will find itself suddenly obsolete in the early decades of the twenty-first century.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

General

> Artillery developed as the means by which an enemy could be hit at longer ranges or with greater effective weight of fire than those which infantry, cavalry and, later, armor could achieve. Artillery has been most prized according to its ability to undertake this task relative to other arms. As a result, at different periods of history artillery has been seen as either the decisive arm on the battlefield or, more often as the arm which merely supports the frontline troops who will decide the outcome of the battle.[1]
>
> J. B. A. Bailey, Field Artillery and Firepower

How will the artillery be seen in the Information Age: King of Battle or digital dinosaur? This thesis examined the developing force structure of the future field artillery with the intent to determine if the artillery is adequately preparing itself for the challenges of the twenty-first century. The thesis researched the specific questions of whether the future artillery force structure would: support Force XXI patterns of operations; support military operations across the spectrum of conflict; and support the integration of future technology. The answers to these questions lay in the doctrinal concepts, organizational structures, and the technologies of the future force. The answers to these questions indicate whether the artillery is on the right azimuth as it moves into the future.

Viewed through a historical perspective, the field artillery has been valued for its ability to mass fires on the enemy at extended ranges relative to the other arms. During the Industrial Age the field

artillery emerged as the greatest killer on the battlefield. The artillery has been a source of responsive and dependable fires in all environments: day or night, good weather or bad, against forces in contact and forces not in contact. In modern warfare the ability to quickly concentrate highly lethal fires against massed enemy formations often proved to be the single most decisive factor. For these reasons the artillery occupied a decisive role in the conflicts of the twentieth century.

Contrary to the premature pronouncements of some, the artillery is not an archaic remnant of the Industrial Age, with little significance to the fluid and dynamic battlefields of the future. Well into the twenty-first century, the field artillery will continue to be valued as a source of responsive and effective fires. The specific circumstances confronting the U.S. Army will continue to require the unique capabilities and characteristics of the artillery. The ability to enable decisive victory with minimal casualties, the ability to respond effectively across the spectrum of conflict, and the ability to effectively integrate and apply developing technology will continue to ensure the decisive role of the King of Battle well into the twenty-first century.

The field artillery has a practice that each and every step in the delivery of fires is checked and double checked to ensure that all rounds are on time and on target. The specific conclusions and recommendations provided in this chapter are offered in much the same spirit. As we embark down the path of change into an uncertain future, we artillerymen must ensure that our concept of fires is forward looking and focused on target. With proper foresight and preparation, the artillery will be the decisive arm of tomorrow's battlefield, just as it was of yesterday's.

Conclusions

The future artillery force structure will effectively support Force XXI, America's Army of the twenty-first century. The future artillery is smarter, more flexible, more survivable, more lethal, and better able to deliver decisive fires. The future weapons systems and munitions are significantly better than their predecessors, and bring whole new capabilities to the battlefield. The future organizations are more adaptive and better able to provide responsive fires. The future operational concepts are more focused on achieving the commander's intent and better suited to the changing dynamics of the future battlefield. The future artillery force is well designed to support the execution of the Force XXI patterns of operations.

This was by no means a foregone conclusion. Many, if not all, of the artillery systems and organizations in Force XXI were initiated and developed for the Army of Excellence, the forward deployed Cold War army designed to take on Warsaw Pact forces in high intensity, combined arms conflict on the European continent. Fortunately, many of the same capabilities that were necessary to defeat massed formations of armored vehicles and artillery have great value for today's power projection force that faces an increasingly uncertain and potentially dangerous spectrum of threats.

The future artillery will effectively support military operations across the entire spectrum of conflict. The future artillery force has been deliberately optimized for conflict at the high end of the threat spectrum model. However, the future systems, organizations and operational concepts developed to enable decisive victory in a major regional contingency also provides an effective capability to operate at the low end of the threat spectrum model. The future artillery has avoided the dangers of overspecialization and structural obsolescence.

The future artillery force will be able to effectively respond to the full range of missions the twenty-first century will bring.

The future artillery force structure will effectively integrate and apply future technologies. The artillery's force modernization plan is fully synchronized with the Army's modernization objectives. Examination of the current Army Science and Technology Plan shows that the artillery's modernization efforts are coordinated and integrated with the Army science and technology organizations, the other battlefield operating systems, and the master plans of individual Army major commands, major subordinate commands, and laboratories. The future artillery force will avoid the danger of technological obsolescence. The future artillery force is structured to take advantage of further technological developments in the areas most likely to continue rapid growth.

The artillery community has been aggressive in defining and anticipating the operating environments of the twenty-first century and identifying the capabilities that will be necessary for the artillery to respond effectively. The results of these deliberations have been generally sound. In most cases, the future artillery force structure has struck an appropriate balance in its mix of cannon and rocket; heavy and light; active and reserve forces. However, there are some areas of concern. Strategic mobility and early entry lethality and survivability are areas that will require further study and action.

As a whole, the Force XXI artillery force structure is no more strategically deployable than the current force structure, but that portion of the force that is deployed will be significantly more capable. The same amount of strategic lift will provide the commander a significant increase in combat power. The combat capability of a Crusader battalion will be much greater than that of a Paladin battalion.

An ATCAS battalion will bring far more capability to the battlefield than an M198 battalion. Once deployed, weapon for weapon and unit for unit, the future artillery force will bring a greatly expanded capability to protect the force, shape the battlespace and conduct decisive operations. However, there is no getting around the fact that the future force structure is not optimized for power projection operations.

The lack of significant improvement of the future artillery force in terms of power projection operations leads to the conclusion that the Army "just doesn't get it." Defeat of the early entry forces is the single greatest area of risk. Most potential enemies are likely to have learned not to allow US forces time to deploy and develop their full combat capabilities. There must be a fundamental shift in the orientation from winning the "main battle" to solving the challenges of strategic mobility and early entry. Most of the current artillery force structure initiatives just tinker around the edges of the problem. We must place greater emphasis on the development of capabilities that will provide our power projection force with the maximum combat power in the least number of air sorties.

The artillery must improve its strategic mobility and early entry lethality and survivability in order to maintain utility in contingency operations requiring a rapid response capability. The forces best suited for these missions are the four active component light divisions. However, under the Force XXI design process there has been no change to the light artillery force structure. The light forces constitute 40 percent of the current active duty force structure. The artillery cannot afford to ignore the modernization of such a large percentage of its force, especially the units most likely to see conflict.

The final recommendations of the Legal Mix VIII study, which will recommend the artillery force structure for the light divisions are not

known at this time, but most indications are that it will remain essentially unchanged. The direct support battalions in a light DIVARTY will continue to be equipped with the M119 towed 105mm cannon. The general support artillery will continue to be external to the division artillery. The oft used expression "too light to fight" will remain a valid criticism of, and potential epitaph for, America's early entry forces unless the artillery takes immediate action to improve its early entry capabilities.

Recommendations

The light divisions have an urgent need for increased lethality and survivability. The artillery can provide immediate and effective solutions to the most pressing threats facing the light forces during the early entry phases of an operation. However, the artillery cannot provide these solutions with the force as currently designed. Upgunning the artillery would give these forces an improved capability to protect the force, shape the battlespace and conduct decisive operations. The artillery must establish a more robust artillery force package for the light divisions.

Based on the analysis of the research questions this thesis recommends the following artillery force structure for the light divisions (see Figure 23 below). The proposed force structure would provide light forces an improved ability to defend itself until the closure of the follow-on forces. The proposed force structure would provide light forces the specific capabilities identified by the Army Science Board as most critical to the success of the early entry forces: (1) the ability to massively suppress and exploit enemy information network; (2) the ability to defend against missile attacks; and (3) the ability to expand battlespace.

The direct support battalions should be equipped with an ultralight weight (ULW) version of the 155mm towed howitzer, not the M119. The proposed ULW 155mm howitzer is a smaller variant of the basic 155mm Light Towed Howitzer (LTH) currently under development by Royal Ordnance for the ATCAS program. The ultralight 155mm howitzer would have a 35 calibre tube and would weigh approximately 7,000 pounds.[2] The ultralight 155mm howitzer and prime mover would be larger and heavier than the M119 and its associated prime mover, the High Mobility Multipurpose Wheeled Vehicle (HMMWV). However, an ULW 155mm howitzer battalion would be slightly less deployable than an M119 battalion, requiring three additional C-17 sorties.[3]

Once on the ground an ultralight 155mm battalion would have the same degree of tactical mobility that the M119 has. The ultralight 155mm howitzer would require a two ton truck (FMTV) as a prime mover, although the heavy duty version of the HMMWV could move the system. The ULW 155mm system would be air transportable by the UH-60 Blackhawk helicopter, enabling rapid maneuver throughout the battlespace. The standard ATCAS with the 39 caliber tube weighs approximately 9000 pounds, which exceeds the lift capability of the UH-60. Further analysis should be done to determine if the greater range of the 39 caliber tube is more valuable than the ability to conduct air mobile operations with the UH-60.

The greatest advantages that the ultralight 155mm howitzer would provide the early entry force are dramatically increased lethality and survivability. The M119 is limited by its lack of range and the capability of the ammunition it can fire. The Early Entry Force Analysis (EEFA) conducted by TRADOC for the Early Entry and Survivability Battle Lab found that the 155mm ATCAS was 50 times more lethal than the 105mm M119.[4] With the ULW 155mm howitzer, light forces will be able to fire the entire 155mm family of munitions (to include DPICM, FASCAM, Copperhead

and SADARM) out to a range of 18 kilometers, and reach 22 kilometers with assisted projectiles. The ULW 155mm howitzer would give light forces the ability to engage at extended ranges with a variety of munitions, including precision guided and smart munitions. The analysis in Chapter 4 demonstrated the contribution to lethality and force protection made by the ability to attack at increased range and with greater lethality.

General support cannon units for light divisions should be equipped with a new type of self-propelled 155mm howitzer system based on a wheeled chassis. Several other nations have already begun to develop wheeled self-propelled 155mm cannon systems, of which the French Giat firm's CAESAR and Sweden's Bofors APS 2000 are excellent examples. Both systems feature a 155mm/52 calibre cannon capable of achieving ranges in excess of 40 kilometers. Both systems feature the on board fire control systems, integrated navigational system, and automated gun laying and positioning systems needed for a shoot and scoot capability. Both systems have the automated capabilities expected of modern cannon systems, but in a much smaller package. The CAESAR system and Italy's Pegaso system are capable of drive on, drive off air transportability aboard the C-130. Such systems would provide light forces almost all the lethality and survivability gains that Paladin and Crusader provide the heavy forces.

Such a system would be exceptionally mobile, providing light forces improved strategic and tactical mobility. Initial estimates show that such a system would require fewer aircraft sorties to deploy than an ATCAS. Towed systems are lighter than self-propelled systems, but they require a separate prime mover, which must be moved too. A towed howitzer without a prime mover is of extremely limited utility. A wheeled SP 155mm howitzer does not require a separate prime mover. The cannon and the prime mover would occupy the same cubic space. It would

be very possible to design a system and configure units that would be more strategically deployable than the ATCAS.

Another significant advantage of this system would provide the light forces is enhanced lethality. The 52-calibre tube would provide a greater range capability. Because of the 9,000 pound weight limitation stated in the ATCAS ORD all of the ATCAS designs have 39-caliber tubes, which limits their range capability to 30 kilometers. The analysis conducted in chapter 4 demonstrated that increased range provides better force exchange ratios by letting friendly forces kill earlier and more often. This increased lethality contributes directly to better force protection.

Once on the ground, units equipped with the wheeled SP 155mm howitzer would have much better tactical mobility and survivability than ATCAS units. Towed systems have relatively poor cross-country mobility, and only a very limited engage and evade capability. The wheeled SP system would offer light forces performance almost the equivalent of the Paladin or Crusader. The wheeled SP 155mm would have a true shoot and scoot capability, and the ability to maneuver deep into the battlespace to strike at critical targets.

The wheeled SP 155mm system would not be air mobile. The ATCAS is designed to be air lifted by either the CH-47D Chinook or the MV-22 Osprey. However, the ULW 155mm systems in the DS units would be able to conduct air mobile operations using either of these rotary wing lift assets. The ULW 155mm system would be better suited for air mobile operations than the ATCAS because of its lighter weight. The 7000 pound weight of the ULW 155mm howitzer would permit the use of the UH-60 as the lift aircraft, or allow more ammunition to be brought on the other type aircraft.

These force structure changes would provide some advantages in the operational pattern of sustain and transition to future operations. Proper design of the ULW 155mm and the wheeled SP 155mm systems would feature common components. This would reduce development costs as well as operations and sustainment costs over the life of the systems. The elimination the 105mm system would create a single caliber cannon force. This would greatly simplify logistics planning and execution and would also provide the opportunity for cost savings across the force. Further artillery munitions development could focus on the 155mm round. The development of a wheeled SP howitzer would reduce the logistics burden faced by combat service support (CSS) units during contingency operations. The advantages of wheeled systems in relation to tracked systems are many: improved strategic mobility, better mobility on roads, improved reliability, and reduced fuel consumption. These are all significant limitations of tracked vehicles, especially when operating in an austere theater with a marginal infrastructure.

The light divisions require the extended range and concentrated firepower that only an artillery rocket system can provide. The light divisions need an organic GS battery composed of nine HIMARS. A modular designed HIMARS battery with three firing platoons would enable the early insertion of an artillery based force protection package. A single platoon slice would provide a significant force protection capability, to include a theater missile defense (TMD) attack operations capability. Three launchers and all the necessary C2 and support vehicles and systems could be projected into the theater on three C-5 sorties, providing an early in capability to protect airfields and ports necessary for the continued build up of forces.

HIMARS offers a truly significant combat capability to warfighters tasked with projecting force into a regional contingency.

The strategic lift requirements of HIMARS are comparatively minimal, and it provides the commander with a truly significant combat multiplier. The single launch pod container (L/PC) or "six-pack" configuration does not limit its lethality. During computer modeling and combat simulations, HIMARS was found to survive as well and be almost as lethal to threat forces as the MLRS.[5] The analysis presented in chapter 4 demonstrated the contribution that just one artillery rocket battery can make in an early entry scenario. With one weapons platform the CINC gets a dramatically improved capability to protect the force, wage command and control warfare, and extend and dominate the battlespace.

All force structure decisions regarding the light forces must account with the imperative of strategic air mobility. A careful balance must be struck between the requirements for lethality, survivability and strategic lift. This force structure proposal for the light divisions would provide these forces a much needed increase in the ability to use fire and maneuver, while maintaining strategic mobility.

No matter how the future artillery force is structured, it remains a system of systems. Any system or network based organization is only as strong as its weakest link. The future artillery force has some weak links that should be addressed.

The artillery must place increased emphasis on its target acquisition capabilities. The future artillery needs to increase the capabilities of its organic target acquisition assets. Current artillery target acquisition assets are designed solely for finding and locating indirect fire systems. The Firefinder radars have proven themselves to be an exceptionally capable counterbattery system. There are current software and material upgrades planned that will significantly extend the capabilities of these systems. However, this is not enough. Artillery units in the Former Soviet Union (FSU) and Warsaw Pact had an organic

radio direction finding (RDF) capability in addition to their counterbattery radars. The addition of an RDF capability would provide an enhanced ability to target enemy information networks. Target acquisition assets are scarce and valuable resources, which have many conflicting demands and priorities placed against them. There is no certainty that relatively limited number of tactical sensors will be able to support all the taskings needed to provide decisive victory.

There must be increased emphasis on developing new and improved artillery munitions. Every weapons system, no matter how sophisticated and capable is nothing more than a delivery platform. Howitzers do not kill, high explosives do the actual killing. Weapons systems are designed to maximize the ability to quickly and accurately deliver munitions against a target, the munition does the rest. However, the weapons platforms get all the attention and RDT&E dollars, while munitions offer the best avenue for improving lethality.

The Army must continue development of artillery projectiles containing multiple precision-guided submunitions, each with a probability of kill (Pk) approaching one. Force XXI must have the ability to engage and rapidly destroy formations of armored vehicles at extended ranges. As long as the threat of massed formations of mechanized armor, infantry fighting vehicles and artillery exists, a "one shot one kill" capability is not good enough. The average number of kills per mission needs to continue to increase. This offers the best return on the development dollar. The current ATACMS initiatives must be sustained, the SADARM P3I program and the MSTAR must be fully funded in the program objective memorandum (POM). The capabilities provided by these systems are too critical to fall victim to budget constraints.

Precision guided munitions (PGMs) have been widely acknowledged as revolutionizing the battlefield. The Army needs to put its money were

its mouth is. The best estimate is that smart munitions will constitute only 2 to 5 percent of the total inventory of the future.[6] The contribution that the ATACMS suite makes to the warfighting ability of Force XXI has been well established, but procurement quantities are low and will constrain our warfighters' ability to fight and win on future battlefields. Force XXI's ability to effectively execute the deep battle will be constrained more by the number of munitions than by the number of delivery systems.

The PW/MSF 1994 AWE showed that the future force had sufficient rocket launchers to execute the deep battle if given sufficient munitions.[7] The Early Entry Force Analysis also showed that the usual constraint is ammunition, not the number of launchers.[8] Doubling the number of MLRS in the force indicates a strong commitment to improving the force's ability to conduct deep strike operations. However, these additional launchers will not provide the desired effects unless sufficient quantities of the MFOM are acquired. Force planners should bear in mind that rocket launchers and munitions are not quite as versatile as cannon systems. The utility of rocket systems in LIC/MOOTW scenarios is limited.

Continued focus needs to be devoted also to lower cost "competent" munitions and those with non-lethal applications. Force XXI will face many threats that will not present the target arrays that PGMs are designed to attack. In low-intensity conflict competent munitions are likely to provide the most operationally and cost effective means of attack. The Army needs to seriously examine the potential for non-traditional uses of the indirect fire system. Many of the LIC/MOOTW missions could require a nonlethal application of indirect fires. Non-lethal munitions could well become the weapons of choice for MOOTW. The indirect fire capability of the artillery could provide an alternative

method to airdrop for delivery of selected materials. An excellent example of what I mean by this is in a recent article in the January 1996 issue of Research, Development & Acquisition magazine that showed an artillery cargo carrying projectile (M483A1) specially adapted to deliver such items as intravenous fluids and small arms ammunition. Such rounds could be used to deliver critically needed materials to military units or civilians that cannot be reached by any other method.

Ascendancy of Fires

The artillery is in the midst of a period of tremendous change. Not in a hundred years has the artillery seen such a period of concentrated change, such a burst of material and operational innovation. In the three decade period preceding World War I, the artillery underwent a similar transformation in technology and tactics that led to the science of indirect fire and the beginning of the modern artillery. Some have predicted that the current period of change will produce another revolution: the ascendancy of fires.

The ascendancy of fires refers to a fundamental change in the relationship between fire and maneuver. The concept aims at achieving decisive results by using firepower of all kinds from longer ranges, much of it indirect, to minimize the usual high casualties of the direct fire battle. Under the ascendancy of fires concept the intent is fight the enemy by fire first, and then by fire and maneuver, so as to avoid the exposure of our forces to the effects of enemy fires. Force XXI units will use long-range fires as the spearhead of the attack to the extent that the ground maneuver forces may only need to mop up after the fires.[9] Fire becomes the primary means to the destruction of enemy forces, maneuver facilitates and exploits the effects of these fires.

There can be no doubt that the field artillery is in the middle of a full blown technological revolution. From sensor to shooter, virtually every aspect of the field artillery battlefield operating system is undergoing significant change for the better. In the span of less than a single decade, the artillery will gain the ability to acquire and attack moving and stationary targets with pinpoint accuracy out to ranges in excess of 300 kilometers. Direct line of sight will not be necessary to enable precision attack of individual vehicles and systems. No longer will dedicated observers be needed to designate targets. Brilliant munitions dispensed over the target area will find their targets and then coordinate the attack amongst themselves. During this time frame the artillery will develop a self-contained and highly responsive hunter-killer capability. Artillery delivered sensors will search the battlefield for targets, guided by gunners sitting on weapons platforms located many miles away, and then destroy them with highly lethal and precise fires.

In the next decade the artillery will gain the ability to maneuver as freely as the armor and infantry. The mobility and survivability of the future artillery platforms will enable entirely new concepts for the use of fires. During this next ten year span the artillery will develop additional capabilities that will blur the distinction between line of sight and non-line of sight weapons systems. In this same time frame the artillery will become increasingly automated and better linked to the other BOS, with the result that fires will be requested, cleared and delivered almost as quickly as the target is seen. Any element of the future force can serve as the trigger, unleashing a deadly stream of fires within seconds.

Technology is transforming the tactical truism--what can be seen can be hit, and what can be hit can be killed--into a far more precise

and deadly battlefield calculus (P_{acq} x P_{hit} x P_{kill} = 1.0). Nothing will be safe from the effects of fires. Not even the uncertain budgetary environment will derail the ongoing military technological revolution. The civilian market will become the biggest driver in the creation of new technologies with military applications. Advances in hand writing recognition technology translate to advances in missile guidance and target recognition. Continuing advances in computers and communications speeds the clearance and coordination of fires. Civilianization of the means of war ensures the continued acceleration of deadly invention.

The application of new technologies into military systems without innovative operational concepts or organizational adaptation does not fundamentally alter the character and conduct of military operations.[10] What matters most to the question of the ascendancy of fires is how the artillery will employ its new capabilities. The tactics, techniques, and procedures are the true measure of the revolution, not the equipment. Ideas matter more than instruments. The future artillery is getting these right. The old patterns of a static and overly centralized fire support system are giving way to an increasingly decentralized, and yet better focused dynamic of fire. The fire support system will become as flexible and responsive as any maneuver system, and the tactics and techniques to exploit these new capabilities are emerging.

The artillery stands on the brink of matching tactics and technology to produce a fundamental change in the way armies will war in the twenty-first century. The artillery of the future will fuse the functions of fire and maneuver to a degree never before seen. The artillery's ability to strike anywhere on the battlefield with great precision and lethality, against moving and stationary, point and area targets will demand change be brought to the battlefields of the future. Units must disperse themselves even further, knowing that to mass is to

invite immediate attack. This increased dispersion will require greater command and control, but to emit radio-electronic signals will be the same as providing a ten-digit grid location. Forces will be stuck on the horns of a dilemma. The actions they take to survive will work against their tactical effectiveness, and the actions they take to be tactically effective will work against their survival.

In all of these changes I see a the making of different revolution, not of the ascendancy of fires, but the fusion of fire and maneuver. No single component of combat power can effectively dominate the entire spectrum of conflict. Only the flexible and responsive application of all the elements of combat power will enable decisive victory. Forces that best combine the elements of combat power will be those most ready for the many challenges of the twenty-first century.

It is possible that the very effectiveness of the future artillery will lead to even more dramatic changes in how wars will be fought. It is certain that forces will find ways to avoid the devastating effects of immediately responsive fires. The likely responses will be asymmetric in nature, decreasingly force on force, fire against fire, and increasingly based on attacks of networks, on the links between systems of systems. The technology of the Information Age will open an entirely new Pandora's box consisting of cyberwar, electronic viruses, electronic counter-measures and electronic counter-counter-measures. The wars of the last half of the twenty-first century are likely to be fought in the realms of cyberspace by computer technicians, hackers and on the tactical and environmental fringes by special operations forces. But that is another subject entirely.

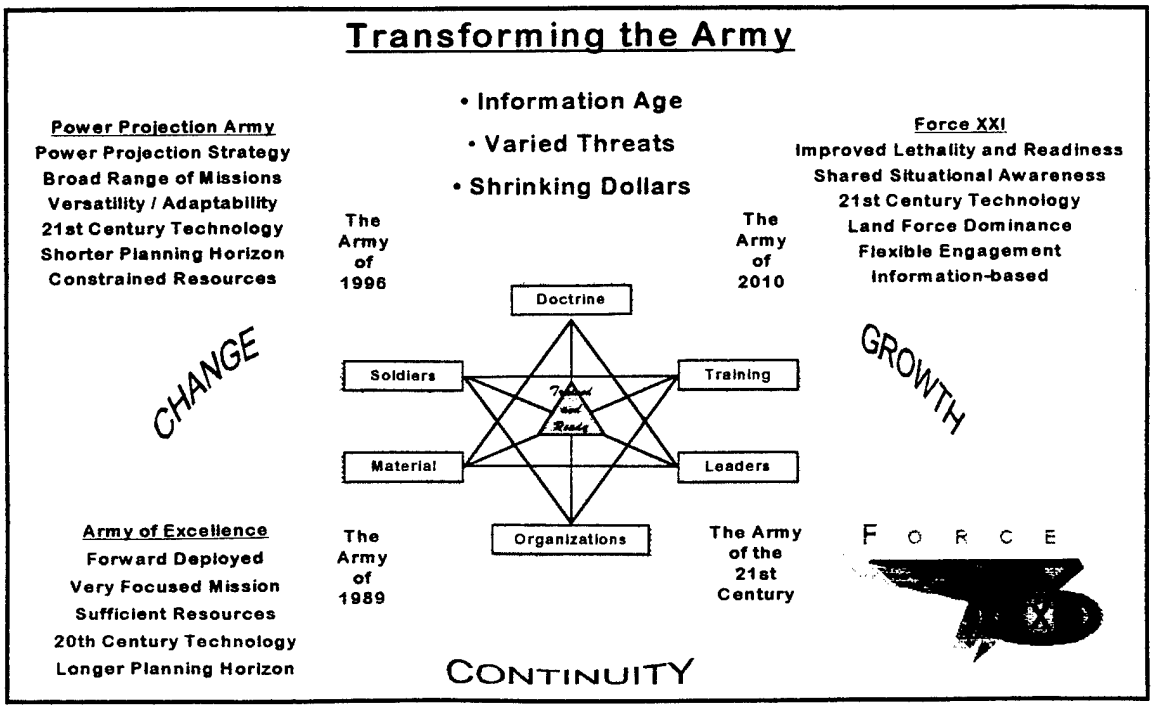

Figure 1. Transforming the Army. Source: Office of the Chief of Staff of the Army, Force XXI America's Army of the 21st Century.

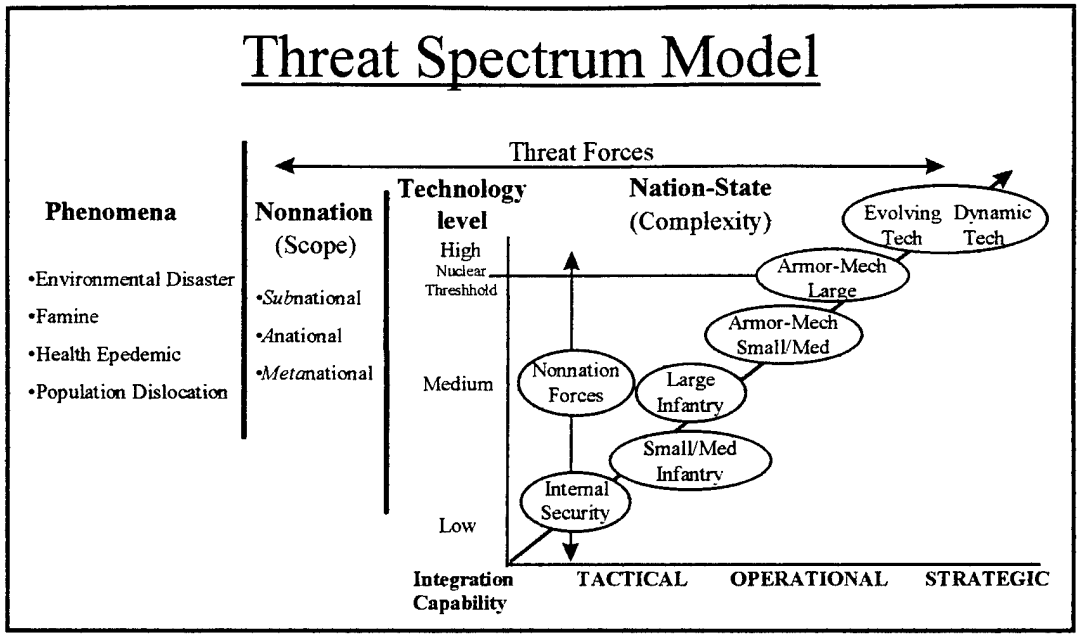

Figure 2. Threat Spectrum Model. Source: TRADOC PAM 525-5, Force XXI Operations.

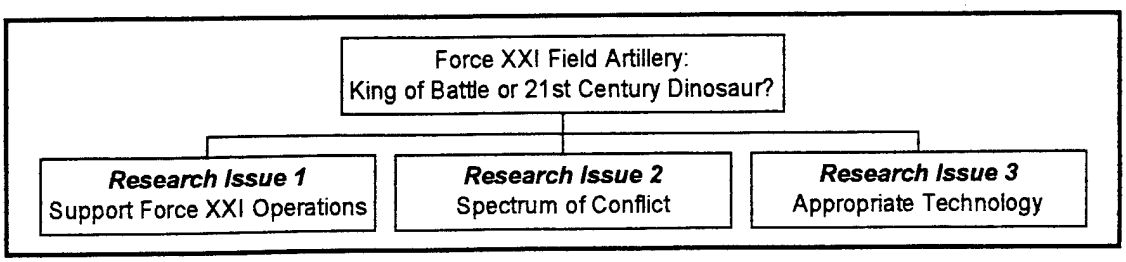

Figure 3. Research Design.

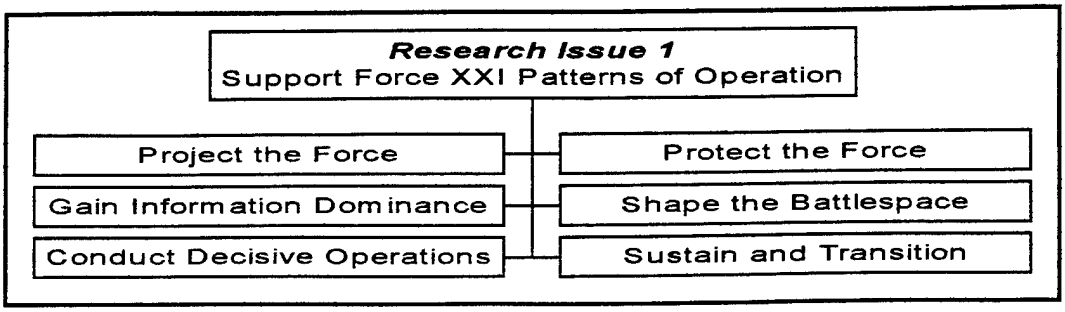

Figure 4. Force XXI Patterns of Operation

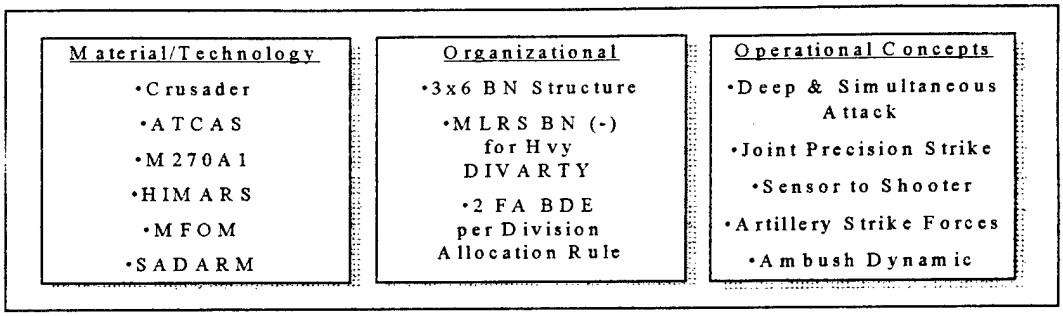

Figure 5. FA Force Structure Initiatives.

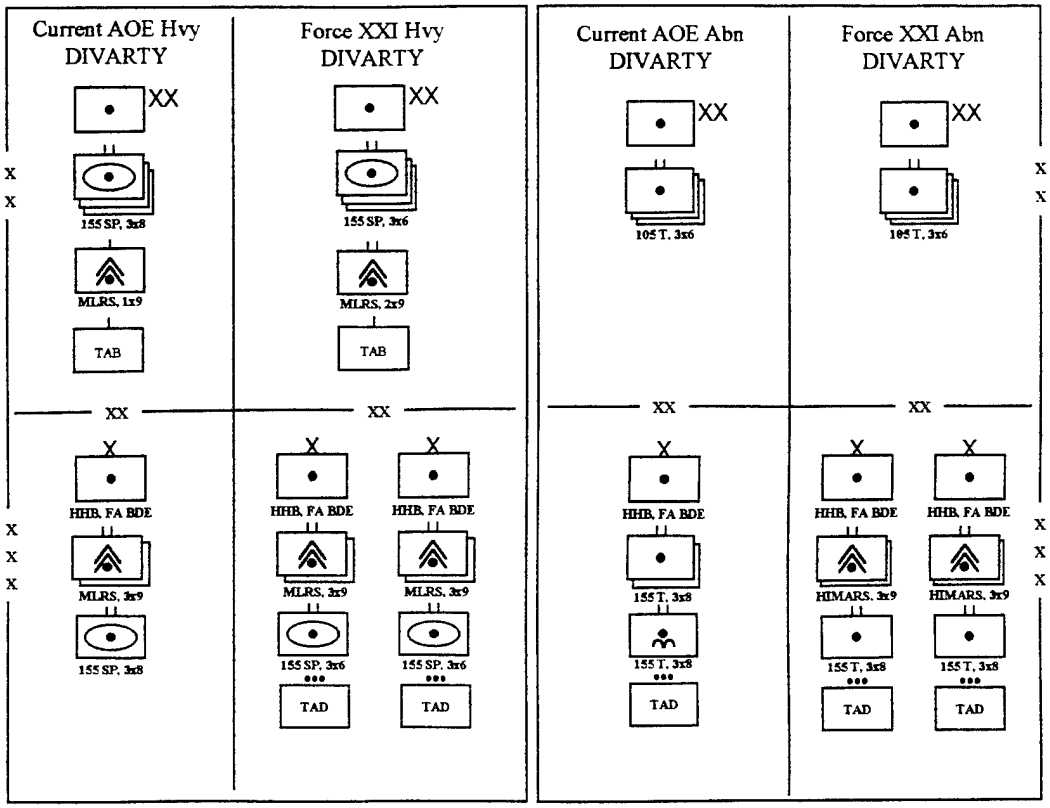

Figure 6. FA Force Structure in Support of a Committed Division.

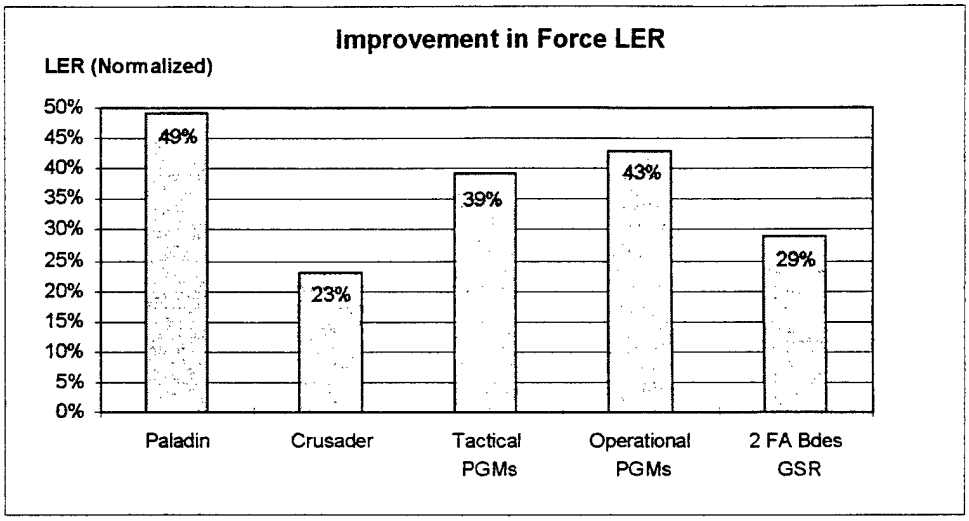

Figure 7. Force XXI FA Contribution to LER.

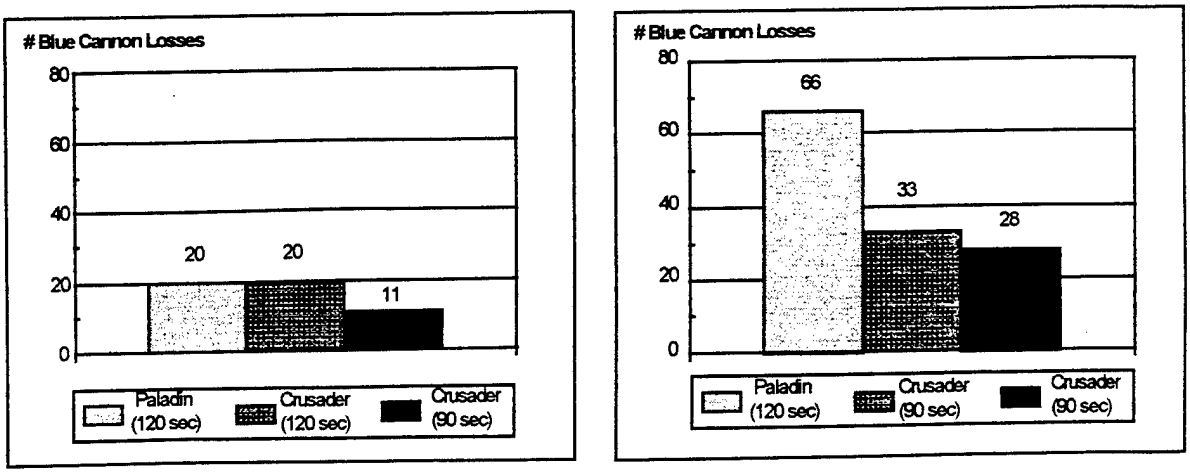

Figure 8. Sensitivity of Cannon Survivability to Mobility. Source: AFAS COEA, p.28.

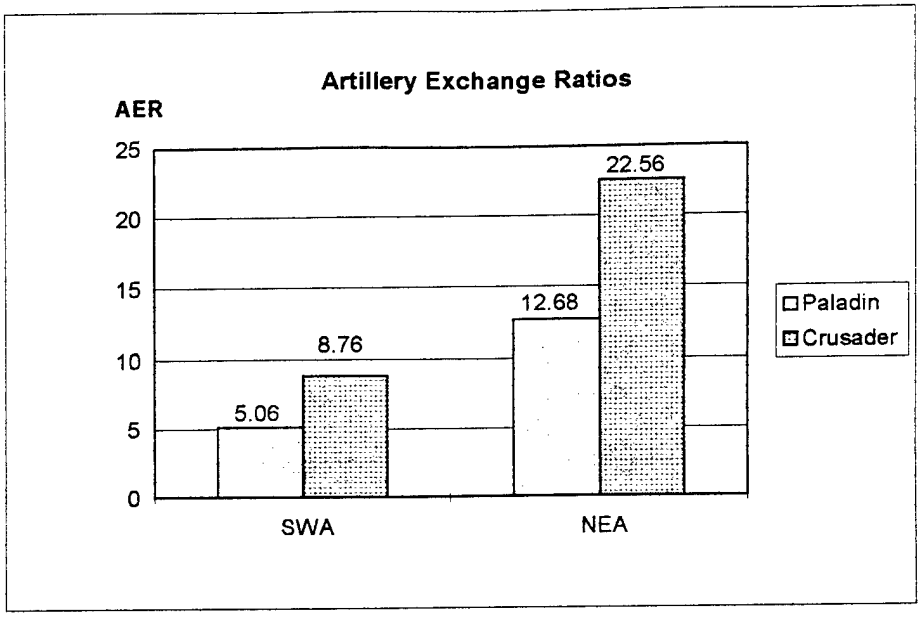

Figure 9. Crusader vs. Paladin AER. Source: AFAS COEA, Figure 28

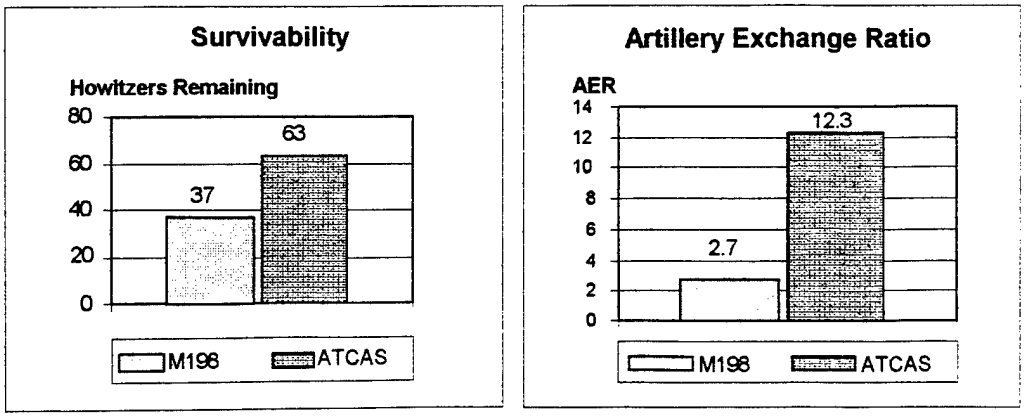

Figure 10. ATCAS Survivability. Source: MSF 2010, selected Fire Support Readings ATCAS Slide Cannon Progroup 5A

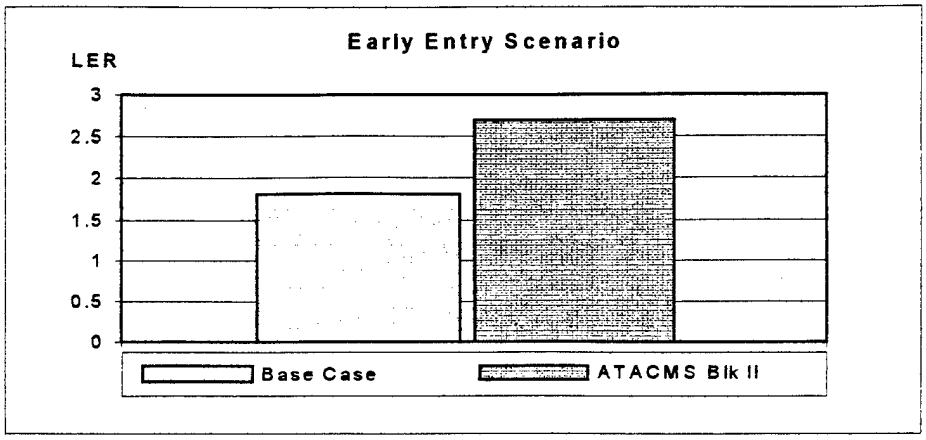

Figure 11. ATACMS Contribution to Early Entry Forces. Source: TRADOC Technical Report TRAC-TR-0195, ATACMS Block II Milestone IV COEA, p. 17.

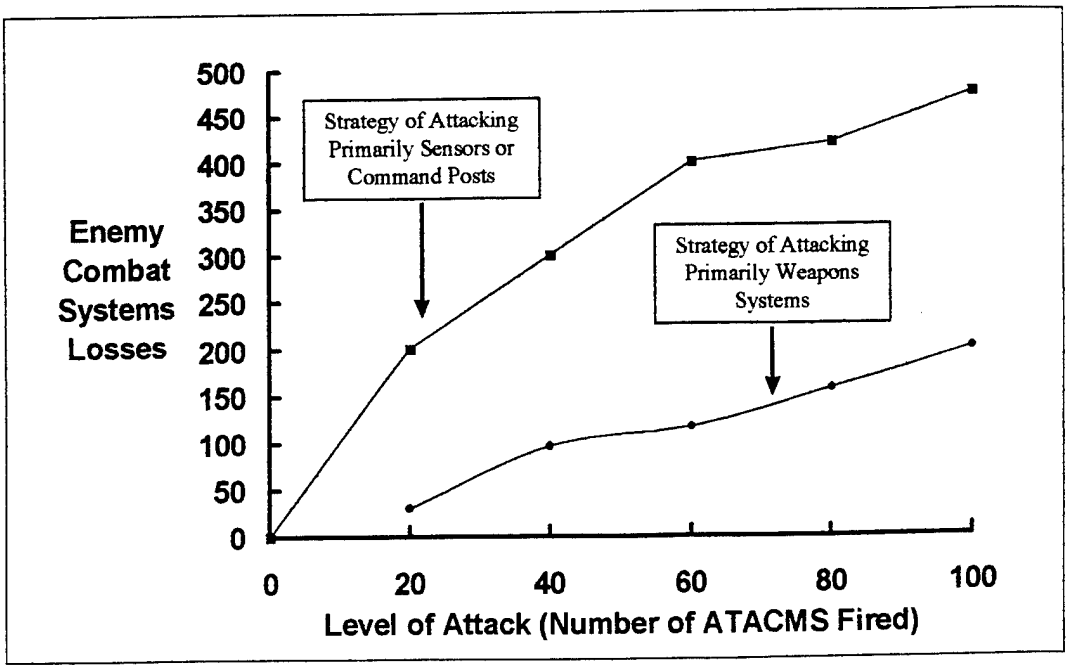

Figure 12. Value Added of FA C2W Attacks. Source: TRADOC Technical Report TRAC-TR-0195, ATACMS Block II Milestone IV COEA, p. 17.

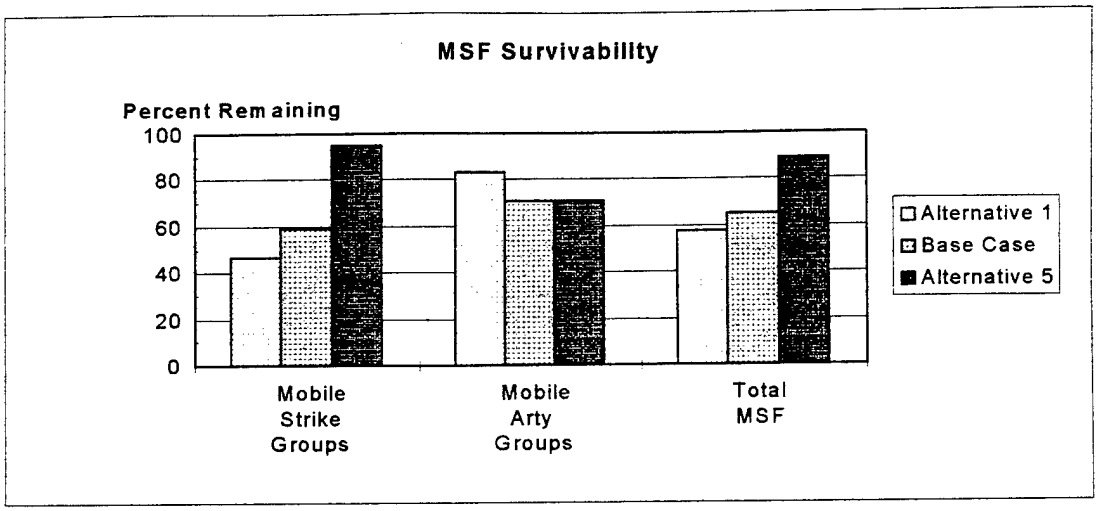

Figure 13. Artillery Deep Attack and MSF Survivability. Source: TRADOC Technical Report TRAC-TR-0195, ATACMS Block II Milestone IV COEA, p. 17.

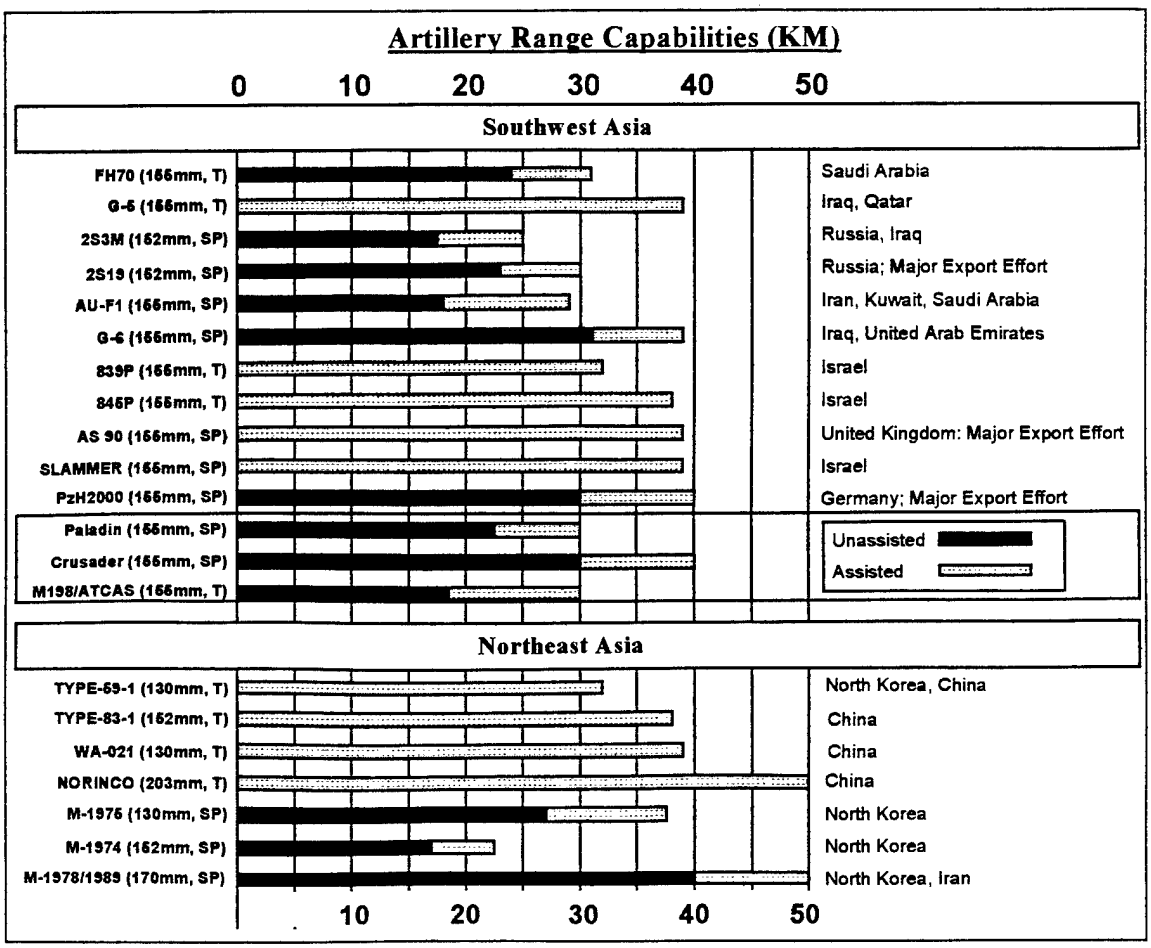

Figure 14. Cannon Range Chart: SWA/NEA.

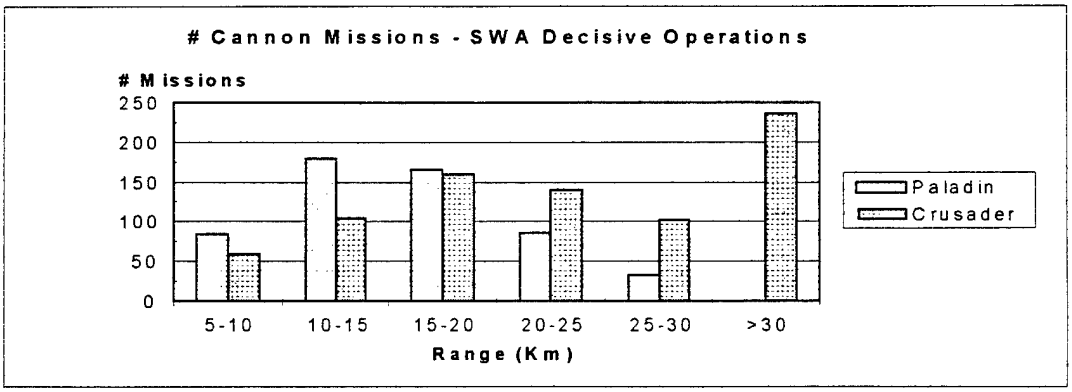

Figure 15. Blue Cannon Missions By Range. Source: AFAS COEA, Figure 17, page 23.

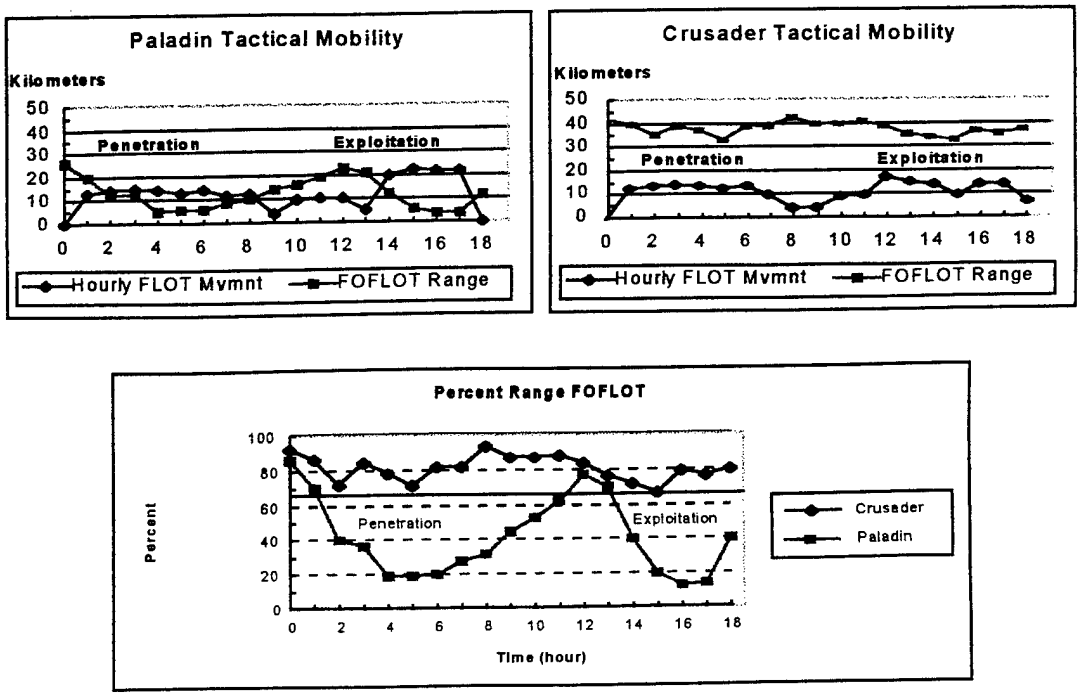

Figure 16. Cannon Tactical Mobility and "Useful" Range. Source: AFAS COEA, Figure 22.

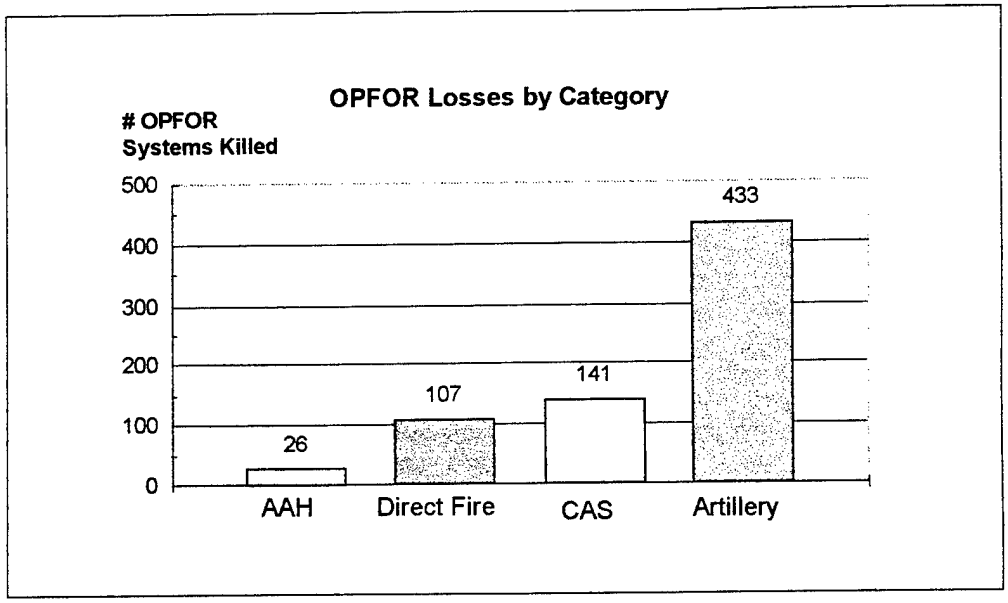

Figure 17. OPFOR Killers-MSF/PW '94. Source: TRADOC Technical Report TRAC-TR-0195, ATACMS Block II Milestone IV COEA, p. 17.

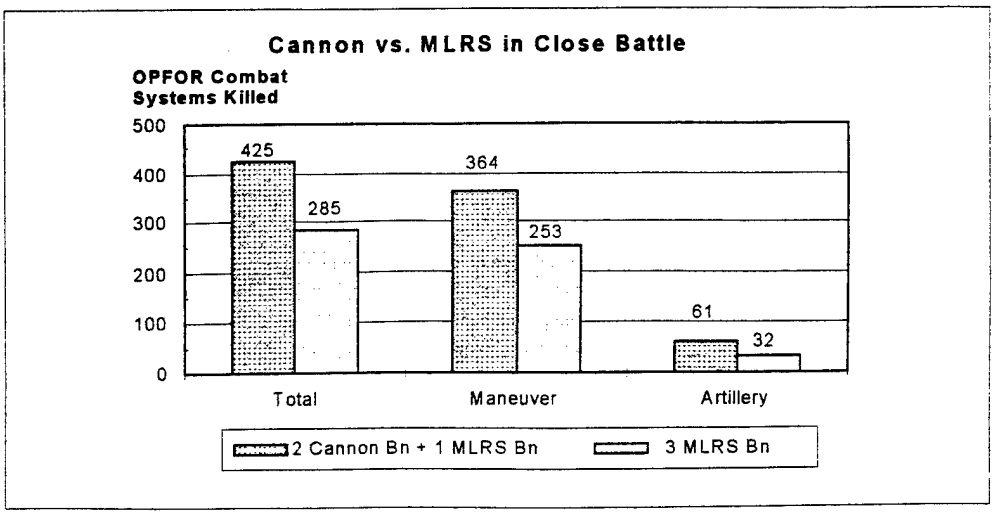

Figure 18. Cannon/MLRS Mix in Close Battle. Source: TRADOC Technical Report TRAC-TR-0195, ATACMS Block II Milestone IV COEA, p. 16.

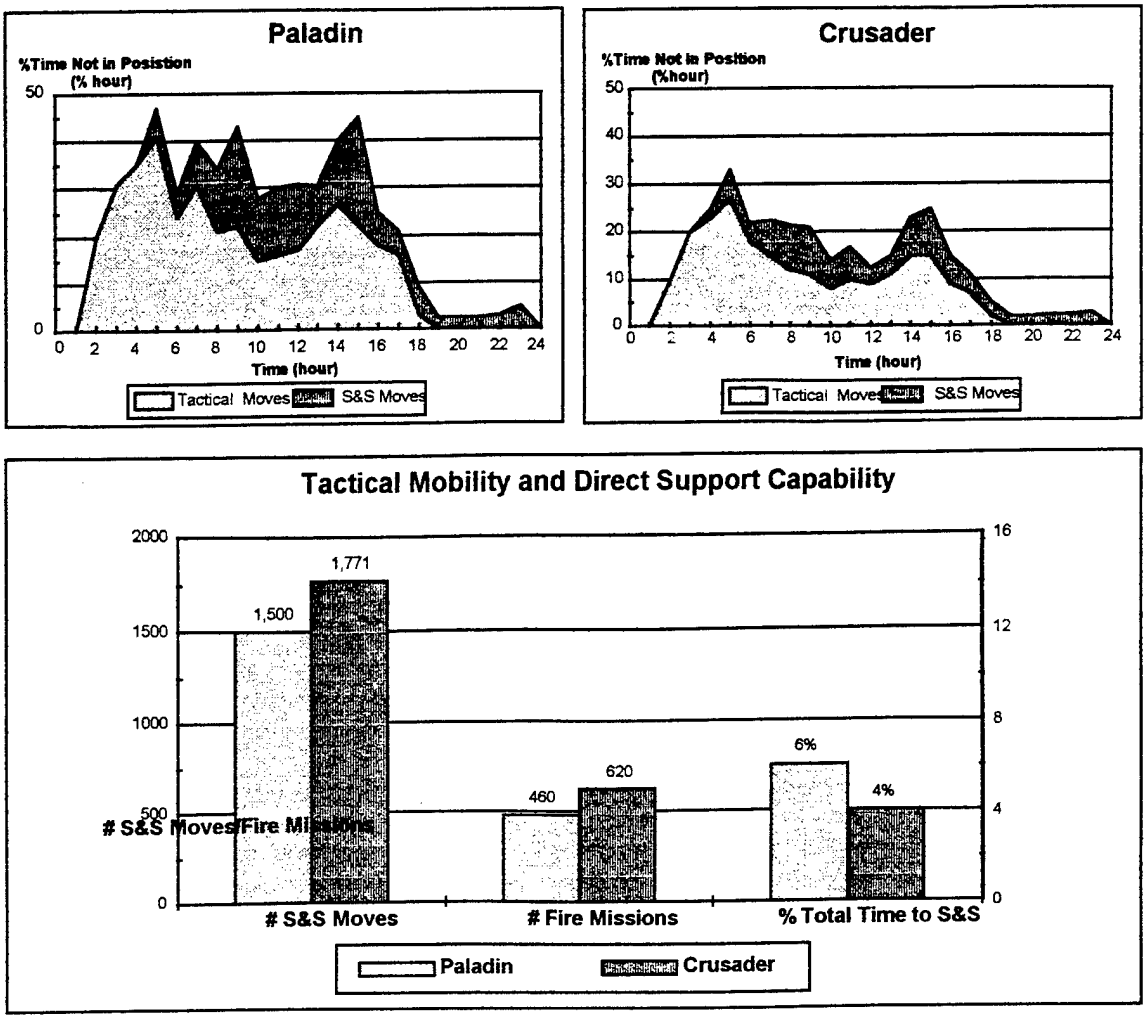

Figure 19. Tactical Mobility and Time in Position. Source: AFAS COEA, p. 27.

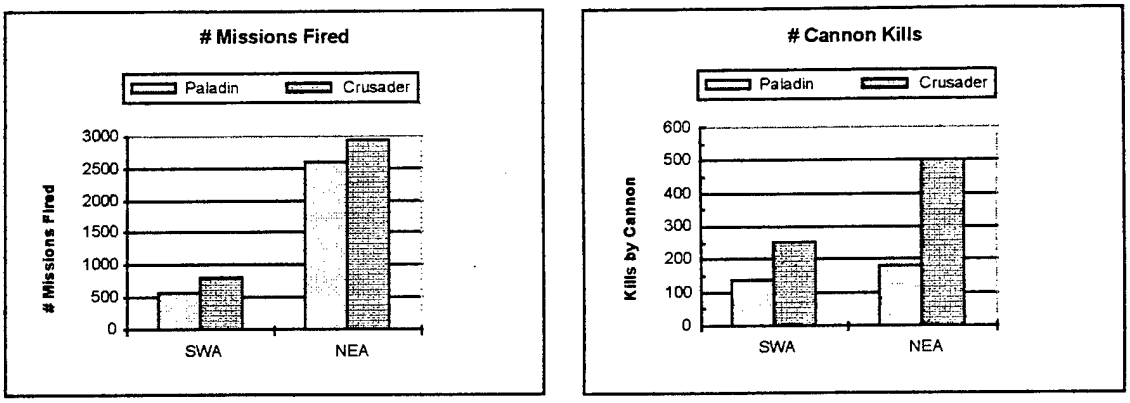

Figure 20. Crusader Responsiveness and Lethality. Source: AFAS COEA., p.23-24.

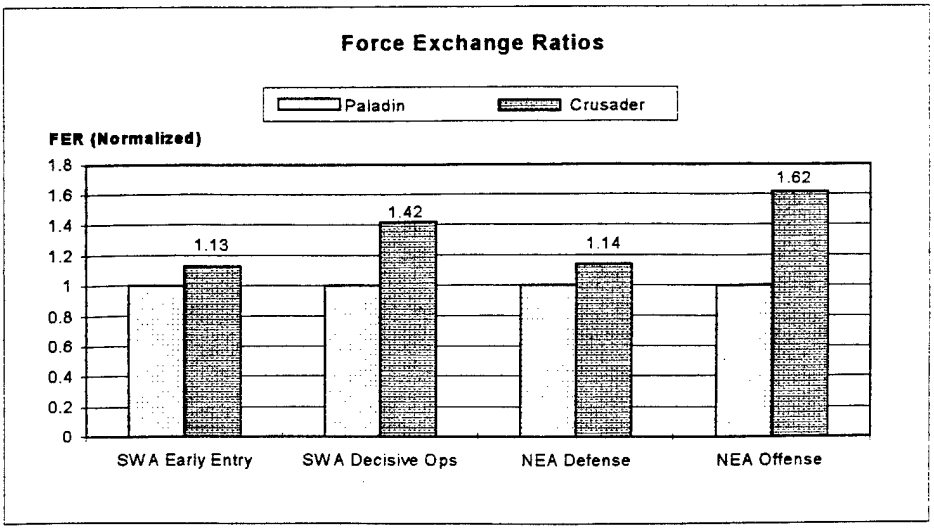

Figure 21. Crusader Contribution to Force Exchange Ratios. Source: Prairie Warrior 1996 Mobile Strike Force 2010 Selected Fire Support Readings, Tab F, TSM - Cannon: Briefing, AFAS ASARC Briefing, date unknown, slide 9c.

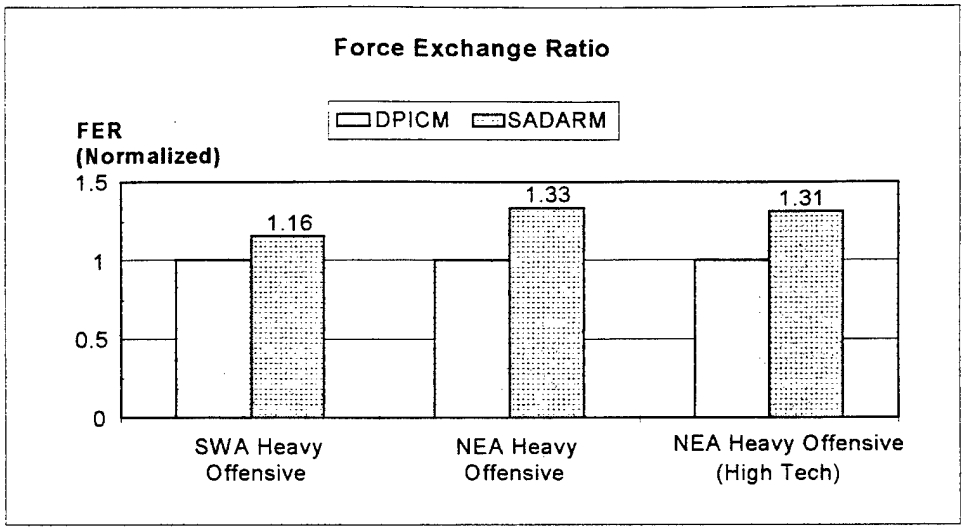

Figure 22. SADARM Contribution to Force Exchange Ratios. Source: Prairie Warrior 1996 Mobile Strike Force 2010 Selected Fire Support Readings, Tab F, TSM - Cannon: Briefing, AFAS ASARC Briefing, date unknown, Slide SADARM force.

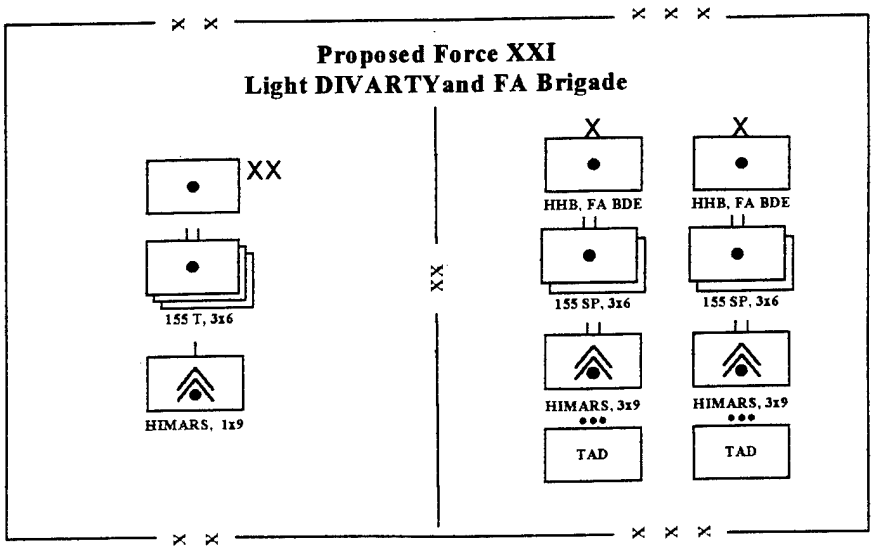

Figure 23. Proposed Light Artillery Force Structure.

FA Weapons	Current AOE Hvy Division	Force XXI Hvy Division	Current AOE Abn Division	Force XXI Abn Division
Cannon Systems	**96**	**90**	**126**	**90**
M109A5, 155mm SP	24			
Paladin, 155mm SP	72			
Crusader, 155mm SP		90		
M119, 105mm T			54	54
M198, 155mm T			72	
ATCAS,155mm T				36
Rocket Systems	**63**	**126**	**27**	**108**
MLRS	63	126	27	
HIMARS				108
Totals (Cannon/Rkt)	**159 (96/63)**	**216 (90/126)**	**153 (126/27)**	**198 (90/108)**
DIVARTY	**81 (72/9)**	**72 (54/18)**	**54 (54/0)**	**54 (54/0)**
FA Brigade(s)	**78(24/54)**	**144 (36/108)**	**99 (72/27)**	**144 (36/108)**

Table 1. FA Weapons in Support of a Committed Division.

Weapon System	Weight (Combat Load)	Dimensions			Air Transportability
		Length	Height	Width	
Paladin	28,850 kg	9.81m	3.24m	3.15m	C-17
Crusader	55,000 kg	10.75m	3.25m	3.25m	C-17
M119	1,860 kg	4.87m	1.37	1.78m	UH-60
M198	7,163 kg	7.44m	2.12m	2.79m	CH-47D/CH-53
ATCAS	4,080 kg	11.86m	3.63m	2.62m	CH-47D/CH-53
MLRS	25,171 kg	6.97m	2.62m	2.97m	C-141B
HIMARS	13,700 kg	6.94m	3.18m	2.4m	C-130

Table 2. FA Weapons System Weights and Dimensions.

ENDNOTES

Chapter 1

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Chapter 2

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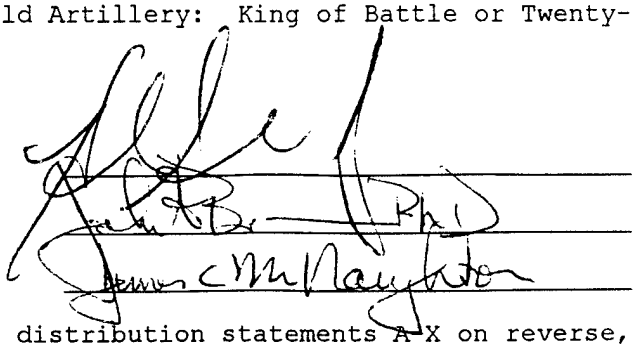

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